Cisco IOS LAN Switching Configuration Guide

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About Cisco IOS and Cisco IOS XE Software Documentation

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This document describes the objectives, audience, conventions, and organization used in Cisco IOS and Cisco IOS XE software documentation, collectively referred to in this document as Cisco IOS documentation. Also included are resources for obtaining technical assistance, additional documentation, and other information from Cisco. This document is organized into the following sections:

- Documentation Objectives, page i
- Audience, page i
- Documentation Conventions, page ii
- Documentation Organization, page iii
- Additional Resources and Documentation Feedback, page xi

Documentation Objectives

Cisco IOS documentation describes the tasks and commands available to configure and maintain Cisco networking devices.

Audience

The Cisco IOS documentation set is i ntended for users who configure and maintain Cisco networking devices (such as routers and switches) but who may not be familiar with the configuration and maintenance tasks, the relationship among tasks, or the Cisco IOS commands necessary to perform particular tasks. The Cisco IOS documentation set is also intended for those users experienced with Cisco IOS who need to know about new features, new configuration options, and new software characteristics in the current Cisco IOS release.

Documentation Conventions

In Cisco IOS documentation, the term *router* may be used to refer to various Cisco products; for example, routers, access servers, and switches. These and other networking devices that support Cisco IOS software are shown interchangeably in examples and are used only for illustrative purposes. An example that shows one product does not necessarily mean that other products are not supported.

This section includes the following topics:

- Typographic Conventions, page ii
- Command Syntax Conventions, page ii
- Software Conventions, page iii
- Reader Alert Conventions, page iii

Typographic Conventions

Cisco IOS documentation uses the following typographic conventions:

Convention	Description
^ or Ctrl	Both the ^ symbol and Ctrl represent the Control (Ctrl) key on a keyboard. For example, the key combination **^D** or **Ctrl-D** means that you hold down the Control key while you press the D key. (Keys are indicated in capital letters but are not case sensitive.)
string	A string is a nonquoted set of characters shown in italics. For example, when setting a Simple Network Management Protocol (SNMP) community string to *public*, do not use quotation marks around the string; otherwise, the string will include the quotation marks.

Command Syntax Conventions

Cisco IOS documentation uses the following command syntax conventions:

Convention	Description
bold	Bold text indicates commands and keywords that you enter as shown.
italic	Italic text indicates arguments for which you supply values.
[x]	Square brackets enclose an optional keyword or argument.
|	A vertical line, called a pipe, indicates a choice within a set of keywords or arguments.
[x | y]	Square brackets enclosing keywords or arguments separated by a pipe indicate an optional choice.
{x | y}	Braces enclosing keywords or arguments separated by a pipe indicate a required choice.
[x {y | z}]	Braces and a pipe within square brackets indicate a required choice within an optional element.

Software Conventions

Cisco IOS uses the following program code conventions:

Convention	Description
`Courier font`	Courier font is used for information that is displayed on a PC or terminal screen.
`Bold Courier font`	Bold Courier font indicates text that the user must enter.
< >	Angle brackets enclose text that is not displayed, such as a password. Angle brackets also are used in contexts in which the italic font style is not supported; for example, ASCII text.
!	An exclamation point at the beginning of a line indicates that the text that follows is a comment, not a line of code. An exclamation point is also displayed by Cisco IOS software for certain processes.
[ ]	Square brackets enclose default responses to system prompts.

Reader Alert Conventions

The Cisco IOS documentation set uses the following conventions for reader alerts:

Caution Means *reader be careful*. In this situation, you might do something that could result in equipment damage or loss of data.

Note Means *reader take note*. Notes contain helpful suggestions or references to material not covered in the manual.

Timesaver Means *the described action saves time*. You can save time by performing the action described in the paragraph.

Documentation Organization

This section describes the Cisco IOS documentation set, how it is organized, and how to access it on Cisco.com. Included are lists of configuration guides, command references, and supplementary references and resources that make up the documentation set. The following topics are included:

- Cisco IOS Documentation Set, page iv
- Cisco IOS Documentation on Cisco.com, page iv
- Configuration Guides, Command References, and Supplementary Resources, page v

Cisco IOS Documentation Set

Cisco IOS documentation consists of the following:

- Release notes and caveats provide information about platform, technology, and feature support for a release and describe severity 1 (catastrophic), severity 2 (severe), and severity 3 (moderate) defects in released Cisco IOS code. Review release notes before other documents to learn whether or not updates have been made to a feature.
- Sets of configuration guides and command references organized by technology and published for each standard Cisco IOS release.
  - Configuration guides—Compilations of documents that provide informational and task-oriented descriptions of Cisco IOS features.
  - Command references—Compilations of command pages that provide detailed information about the commands used in the Cisco IOS features and processes that make up the related configuration guides. For each technology, there is a single command reference that covers all Cisco IOS releases and that is updated at each standard release.
- Lists of all the commands in a specific release and all commands that are new, modified, removed, or replaced in the release.
- Command reference book for **debug** commands. Command pages are listed in alphabetical order.
- Reference book for system messages for all Cisco IOS releases.

Cisco IOS Documentation on Cisco.com

The following sections describe the documentation organization and how to access various document types.

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

New Features List

The New Features List for each release provides a list of all features in the release with hyperlinks to the feature guides in which they are documented.

Feature Guides

Cisco IOS features are documented in feature guides. Feature guides describe one feature or a group of related features that are supported on many different software releases and platforms. Your Cisco IOS software release or platform may not support all the features documented in a feature guide. See the Feature Information table at the end of the feature guide for information about which features in that guide are supported in your software release.

Configuration Guides

Configuration guides are provided by technology and release and comprise a set of individual feature guides relevant to the release and technology.

Command References

Command reference books describe Cisco IOS commands that are supported in many different software releases and on many different platforms. The books are provided by technology. For information about all Cisco IOS commands, use the Command Lookup Tool at http://tools.cisco.com/Support/CLILookup or the *Cisco IOS Master Command List, All Releases*, at http://www.cisco.com/en/US/docs/ios/mcl/all_release/all_mcl.html.

Cisco IOS Supplementary Documents and Resources

Supplementary documents and resources are listed in Table 2 on page xi.

Configuration Guides, Command References, and Supplementary Resources

Table 1 lists, in alphabetical order, Cisco IOS and Cisco IOS XE software configuration guides and command references, including brief descriptions of the contents of the documents. The Cisco IOS command references are comprehensive, meaning that they include commands for both Cisco IOS software and Cisco IOS XE software, for all releases. The configuration guides and command references support many different software releases and platforms. Your Cisco IOS software release or platform may not support all these technologies.

For additional information about configuring and operating specific networking devices, go to the Product Support area of Cisco.com at http://www.cisco.com/web/psa/products/index.html.

Table 2 lists documents and resources that supplement the Cisco IOS software configuration guides and command references. These supplementary resources include release notes and caveats; master command lists; new, modified, removed, and replaced command lists; system messages; and the debug command reference.

Table 1 Cisco IOS and Cisco IOS XE Configuration Guides and Command References

Configuration Guide and Command Reference Titles	Features/Protocols/Technologies
Cisco IOS AppleTalk Configuration Guide *Cisco IOS XE AppleTalk Configuration Guide* *Cisco IOS AppleTalk Command Reference*	AppleTalk protocol.
Cisco IOS Asynchronous Transfer Mode Configuration Guide *Cisco IOS Asynchronous Transfer Mode Command Reference*	LAN ATM, multiprotocol over ATM (MPoA), and WAN ATM.

Table 1 Cisco IOS and Cisco IOS XE Configuration Guides and Command References (continued)

Configuration Guide and Command Reference Titles	Features/Protocols/Technologies
Cisco IOS Bridging and IBM Networking Configuration Guide *Cisco IOS Bridging Command Reference* *Cisco IOS IBM Networking Command Reference*	• Transparent and source-route transparent (SRT) bridging, source-route bridging (SRB), Token Ring Inter-Switch Link (TRISL), and token ring route switch module (TRRSM). • Data-link switching plus (DLSw+), serial tunnel (STUN), block serial tunnel (BSTUN); logical link control, type 2 (LLC2), synchronous data link control (SDLC); IBM Network Media Translation, including Synchronous Data Logical Link Control (SDLLC) and qualified LLC (QLLC); downstream physical unit (DSPU), Systems Network Architecture (SNA) service point, SNA frame relay access, advanced peer-to-peer networking (APPN), native client interface architecture (NCIA) client/server topologies, and IBM Channel Attach.
Cisco IOS Broadband and DSL Configuration Guide *Cisco IOS XE Broadband and DSL Configuration Guide* *Cisco IOS Broadband and DSL Command Reference*	Point-to-Point Protocol (PPP) over ATM (PPPoA) and PPP over Ethernet (PPPoE).
Cisco IOS Carrier Ethernet Configuration Guide *Cisco IOS Carrier Ethernet Command Reference*	Connectivity fault management (CFM), Ethernet Local Management Interface (ELMI), IEEE 802.3ad link bundling, Link Layer Discovery Protocol (LLDP), media endpoint discovery (MED), and operations, administration, and maintenance (OAM).
Cisco IOS Configuration Fundamentals Configuration Guide *Cisco IOS XE Configuration Fundamentals Configuration Guide* *Cisco IOS Configuration Fundamentals Command Reference*	Autoinstall, Setup, Cisco IOS command-line interface (CLI), Cisco IOS file system (IFS), Cisco IOS web browser user interface (UI), basic file transfer services, and file management.
Cisco IOS DECnet Configuration Guide *Cisco IOS XE DECnet Configuration Guide* *Cisco IOS DECnet Command Reference*	DECnet protocol.
Cisco IOS Dial Technologies Configuration Guide *Cisco IOS XE Dial Technologies Configuration Guide* *Cisco IOS Dial Technologies Command Reference*	Asynchronous communications, dial backup, dialer technology, dial-in terminal services and AppleTalk remote access (ARA), large scale dialout, dial-on-demand routing, dialout, modem and resource pooling, ISDN, multilink PPP (MLP), PPP, virtual private dialup network (VPDN).
Cisco IOS Flexible NetFlow Configuration Guide *Cisco IOS Flexible NetFlow Command Reference*	Flexible NetFlow.

Table 1 Cisco IOS and Cisco IOS XE Configuration Guides and Command References (continued)

Configuration Guide and Command Reference Titles	Features/Protocols/Technologies
Cisco IOS H.323 Configuration Guide	Gatekeeper enhancements for managed voice services, Gatekeeper Transaction Message Protocol, gateway codec order preservation and shutdown control, H.323 dual tone multifrequency relay, H.323 version 2 enhancements, Network Address Translation (NAT) support of H.323 v2 Registration, Admission, and Status (RAS) protocol, tokenless call authorization, and VoIP gateway trunk and carrier-based routing.
Cisco IOS High Availability Configuration Guide *Cisco IOS XE High Availability Configuration Guide* *Cisco IOS High Availability Command Reference*	A variety of High Availability (HA) features and technologies that are available for different network segments (from enterprise access to service provider core) to facilitate creation of end-to-end highly available networks. Cisco IOS HA features and technologies can be categorized in three key areas: system-level resiliency, network-level resiliency, and embedded management for resiliency.
Cisco IOS Integrated Session Border Controller Command Reference	A VoIP-enabled device that is deployed at the edge of networks. An SBC is a toolkit of functions, such as signaling interworking, network hiding, security, and quality of service (QoS).
Cisco IOS Intelligent Service Gateway Configuration Guide *Cisco IOS Intelligent Service Gateway Command Reference*	Subscriber identification, service and policy determination, session creation, session policy enforcement, session life-cycle management, accounting for access and service usage, session state monitoring.
Cisco IOS Interface and Hardware Component Configuration Guide *Cisco IOS XE Interface and Hardware Component Configuration Guide* *Cisco IOS Interface and Hardware Component Command Reference*	LAN interfaces, logical interfaces, serial interfaces, virtual interfaces, and interface configuration.
Cisco IOS IP Addressing Services Configuration Guide *Cisco IOS XE Addressing Services Configuration Guide* *Cisco IOS IP Addressing Services Command Reference*	Address Resolution Protocol (ARP), Network Address Translation (NAT), Domain Name System (DNS), Dynamic Host Configuration Protocol (DHCP), and Next Hop Address Resolution Protocol (NHRP).
Cisco IOS IP Application Services Configuration Guide *Cisco IOS XE IP Application Services Configuration Guide* *Cisco IOS IP Application Services Command Reference*	Enhanced Object Tracking (EOT), Gateway Load Balancing Protocol (GLBP), Hot Standby Router Protocol (HSRP), IP Services, Server Load Balancing (SLB), Stream Control Transmission Protocol (SCTP), TCP, Web Cache Communication Protocol (WCCP), User Datagram Protocol (UDP), and Virtual Router Redundancy Protocol (VRRP).
Cisco IOS IP Mobility Configuration Guide *Cisco IOS IP Mobility Command Reference*	Mobile ad hoc networks (MANet) and Cisco mobile networks.
Cisco IOS IP Multicast Configuration Guide *Cisco IOS XE IP Multicast Configuration Guide* *Cisco IOS IP Multicast Command Reference*	Protocol Independent Multicast (PIM) sparse mode (PIM-SM), bidirectional PIM (bidir-PIM), Source Specific Multicast (SSM), Multicast Source Discovery Protocol (MSDP), Internet Group Management Protocol (IGMP), and Multicast VPN (MVPN).

Table 1 Cisco IOS and Cisco IOS XE Configuration Guides and Command References (continued)

Configuration Guide and Command Reference Titles	Features/Protocols/Technologies
Cisco IOS IP Routing Protocols Configuration Guide *Cisco IOS XE IP Routing Protocols Configuration Guide* *Cisco IOS IP Routing Protocols Command Reference*	Border Gateway Protocol (BGP), multiprotocol BGP, multiprotocol BGP extensions for IP multicast, bidirectional forwarding detection (BFD), Enhanced Interior Gateway Routing Protocol (EIGRP), Interior Gateway Routing Protocol (IGRP), Intermediate System-to-Intermediate System (IS-IS), on-demand routing (ODR), Open Shortest Path First (OSPF), and Routing Information Protocol (RIP).
Cisco IOS IP SLAs Configuration Guide *Cisco IOS XE IP SLAs Configuration Guide* *Cisco IOS IP SLAs Command Reference*	Cisco IOS IP Service Level Agreements (IP SLAs).
Cisco IOS IP Switching Configuration Guide *Cisco IOS XE IP Switching Configuration Guide* *Cisco IOS IP Switching Command Reference*	Cisco Express Forwarding, fast switching, and Multicast Distributed Switching (MDS).
Cisco IOS IPv6 Configuration Guide *Cisco IOS XE IPv6 Configuration Guide* *Cisco IOS IPv6 Command Reference*	For IPv6 features, protocols, and technologies, go to the IPv6 "Start Here" document at the following URL: http://www.cisco.com/en/US/docs/ios/ipv6/configuration/guide/ip6-roadmap.html
Cisco IOS ISO CLNS Configuration Guide *Cisco IOS XE ISO CLNS Configuration Guide* *Cisco IOS ISO CLNS Command Reference*	ISO connectionless network service (CLNS).
Cisco IOS LAN Switching Configuration Guide *Cisco IOS XE LAN Switching Configuration Guide* *Cisco IOS LAN Switching Command Reference*	VLANs, Inter-Switch Link (ISL) encapsulation, IEEE 802.10 encapsulation, IEEE 802.1Q encapsulation, and multilayer switching (MLS).
Cisco IOS Mobile Wireless Gateway GPRS Support Node Configuration Guide *Cisco IOS Mobile Wireless Gateway GPRS Support Node Command Reference*	Cisco IOS Gateway GPRS Support Node (GGSN) in a 2.5-generation general packet radio service (GPRS) and 3-generation universal mobile telecommunication system (UMTS) network.
Cisco IOS Mobile Wireless Home Agent Configuration Guide *Cisco IOS Mobile Wireless Home Agent Command Reference*	Cisco Mobile Wireless Home Agent, an anchor point for mobile terminals for which mobile IP or proxy mobile IP services are provided.
Cisco IOS Mobile Wireless Packet Data Serving Node Configuration Guide *Cisco IOS Mobile Wireless Packet Data Serving Node Command Reference*	Cisco Packet Data Serving Node (PDSN), a wireless gateway that is between the mobile infrastructure and standard IP networks and that enables packet data services in a code division multiple access (CDMA) environment.
Cisco IOS Mobile Wireless Radio Access Networking Configuration Guide *Cisco IOS Mobile Wireless Radio Access Networking Command Reference*	Cisco IOS radio access network products.

Table 1 Cisco IOS and Cisco IOS XE Configuration Guides and Command References (continued)

Configuration Guide and Command Reference Titles	Features/Protocols/Technologies
Cisco IOS Multiprotocol Label Switching Configuration Guide *Cisco IOS XE Multiprotocol Label Switching Configuration Guide* *Cisco IOS Multiprotocol Label Switching Command Reference*	MPLS Label Distribution Protocol (LDP), MPLS Layer 2 VPNs, MPLS Layer 3 VPNs, MPLS Traffic Engineering (TE), and MPLS Embedded Management (EM) and MIBs.
Cisco IOS Multi-Topology Routing Configuration Guide *Cisco IOS Multi-Topology Routing Command Reference*	Unicast and multicast topology configurations, traffic classification, routing protocol support, and network management support.
Cisco IOS NetFlow Configuration Guide *Cisco IOS XE NetFlow Configuration Guide* *Cisco IOS NetFlow Command Reference*	Network traffic data analysis, aggregation caches, export features.
Cisco IOS Network Management Configuration Guide *Cisco IOS XE Network Management Configuration Guide* *Cisco IOS Network Management Command Reference*	Basic system management; system monitoring and logging; troubleshooting, logging, and fault management; Cisco Discovery Protocol; Cisco IOS Scripting with Tool Control Language (Tcl); Cisco networking services (CNS); DistributedDirector; Embedded Event Manager (EEM); Embedded Resource Manager (ERM); Embedded Syslog Manager (ESM); HTTP; Remote Monitoring (RMON); SNMP; and VPN Device Manager Client for Cisco IOS Software (XSM Configuration).
Cisco IOS Novell IPX Configuration Guide *Cisco IOS XE Novell IPX Configuration Guide* *Cisco IOS Novell IPX Command Reference*	Novell Internetwork Packet Exchange (IPX) protocol.
Cisco IOS Optimized Edge Routing Configuration Guide *Cisco IOS Optimized Edge Routing Command Reference*	Optimized edge routing (OER) monitoring, policy configuration, routing control, logging and reporting, and VPN IPsec/generic routing encapsulation (GRE) tunnel interface optimization.
Cisco IOS Quality of Service Solutions Configuration Guide *Cisco IOS XE Quality of Service Solutions Configuration Guide* *Cisco IOS Quality of Service Solutions Command Reference*	Class-based weighted fair queuing (CBWFQ), custom queuing, distributed traffic shaping (DTS), generic traffic shaping (GTS), IP- to-ATM class of service (CoS), low latency queuing (LLQ), modular QoS CLI (MQC), Network-Based Application Recognition (NBAR), priority queuing, Security Device Manager (SDM), Multilink PPP (MLPPP) for QoS, header compression, AutoQoS, QoS features for voice, Resource Reservation Protocol (RSVP), weighted fair queuing (WFQ), and weighted random early detection (WRED).
Cisco IOS Security Configuration Guide *Cisco IOS XE Security Configuration Guide* *Cisco IOS Security Command Reference*	Access control lists (ACLs), authentication, authorization, and accounting (AAA), firewalls, IP security and encryption, neighbor router authentication, network access security, network data encryption with router authentication, public key infrastructure (PKI), RADIUS, TACACS+, terminal access security, and traffic filters.

Table 1 Cisco IOS and Cisco IOS XE Configuration Guides and Command References (continued)

Configuration Guide and Command Reference Titles	Features/Protocols/Technologies
Cisco IOS Service Selection Gateway Configuration Guide *Cisco IOS Service Selection Gateway Command Reference*	Subscriber authentication, service access, and accounting.
Cisco IOS Software Activation Configuration Guide *Cisco IOS Software Activation Command Reference*	An orchestrated collection of processes and components to activate Cisco IOS software feature sets by obtaining and validating Cisco software licenses.
Cisco IOS Software Modularity Installation and Configuration Guide *Cisco IOS Software Modularity Command Reference*	Installation and basic configuration of software modularity images, including installations on single and dual route processors, installation rollbacks, software modularity binding, software modularity processes and patches.
Cisco IOS Terminal Services Configuration Guide *Cisco IOS Terminal Services Command Reference* *Cisco IOS XE Terminal Services Command Reference*	DEC, local-area transport (LAT), and X.25 packet assembler/disassembler (PAD).
Cisco IOS Virtual Switch Command Reference	Virtual switch redundancy, high availability, and packet handling; converting between standalone and virtual switch modes; virtual switch link (VSL); Virtual Switch Link Protocol (VSLP). **Note** For information about virtual switch configuration, refer to the product-specific software configuration information for the Cisco Catalyst 6500 series switch or for the Metro Ethernet 6500 series switch.
Cisco IOS Voice Configuration Library *Cisco IOS Voice Command Reference*	Cisco IOS support for voice call control protocols, interoperability, physical and virtual interface management, and troubleshooting. The library includes documentation for IP telephony applications.
Cisco IOS VPDN Configuration Guide *Cisco IOS XE VPDN Configuration Guide* *Cisco IOS VPDN Command Reference*	Layer 2 Tunneling Protocol (L2TP) dial-out load balancing and redundancy, L2TP extended failover, L2TP security VPDN, multihop by Dialed Number Identification Service (DNIS), timer and retry enhancements for L2TP and Layer 2 Forwarding (L2F), RADIUS Attribute 82: tunnel assignment ID, shell-based authentication of VPDN users, tunnel authentication via RADIUS on tunnel terminator.
Cisco IOS Wide-Area Networking Configuration Guide *Cisco IOS XE Wide-Area Networking Configuration Guide* *Cisco IOS Wide-Area Networking Command Reference*	Frame Relay, Layer 2 Tunneling Protocol Version 3 (L2TPv3), Link Access Procedure, Balanced (LAPB), Switched Multimegabit Data Service (SMDS), and X.25.
Cisco IOS Wireless LAN Configuration Guide *Cisco IOS Wireless LAN Command Reference*	Broadcast key rotation, IEEE 802.11x support, IEEE 802.1x authenticator, IEEE 802.1x local authentication service for Extensible Authentication Protocol-Flexible Authentication via Secure Tunneling (EAP-FAST), Multiple Basic Service Set ID (BSSID), Wi-Fi Multimedia (WMM) required elements, and Wi-Fi Protected Access (WPA).

Table 2 Cisco IOS Supplementary Documents and Resources

Document Title	Description
Cisco IOS Master Command List, All Releases	Alphabetical list of all the commands documented in all Cisco IOS releases.
Cisco IOS New, Modified, Removed, and Replaced Commands	List of all the new, modified, removed, and replaced commands for a Cisco IOS release.
Cisco IOS Software System Messages	List of Cisco IOS system messages and descriptions. System messages may indicate problems with your system; be informational only; or may help diagnose problems with communications lines, internal hardware, or the system software.
Cisco IOS Debug Command Reference	Alphabetical list of **debug** commands including brief descriptions of use, command syntax, and usage guidelines.
Release Notes and Caveats	Information about new and changed features, system requirements, and other useful information about specific software releases; information about defects in specific Cisco IOS software releases.
MIBs	Files used for network monitoring. To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator at the following URL: http://www.cisco.com/go/mibs
RFCs	Standards documents maintained by the Internet Engineering Task Force (IETF) that Cisco IOS documentation references where applicable. The full text of referenced RFCs may be obtained at the following URL: http://www.rfc-editor.org/

Additional Resources and Documentation Feedback

What's New in Cisco Product Documentation is published monthly and describes all new and revised Cisco technical documentation. The *What's New in Cisco Product Documentation* publication also provides information about obtaining the following resources:

- Technical documentation
- Cisco product security overview
- Product alerts and field notices
- Technical assistance

Cisco IOS technical documentation includes embedded feedback forms where you can rate documents and provide suggestions for improvement. Your feedback helps us improve our documentation.

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Using the Command-Line Interface in Cisco IOS and Cisco IOS XE Software

Last updated: August 6, 2008

This document provides basic information about the command-line interface (CLI) in Cisco IOS and Cisco IOS XE software and how you can use some of the CLI features. This document contains the following sections:

- Initially Configuring a Device, page i
- Using the CLI, page ii
- Saving Changes to a Configuration, page xii
- Additional Information, page xii

For more information about using the CLI, see the "Using the Cisco IOS Command-Line Interface" section of the *Cisco IOS Configuration Fundamentals Configuration Guide*.

For information about the software documentation set, see the "About Cisco IOS and Cisco IOS XE Software Documentation" document.

Initially Configuring a Device

Initially configuring a device varies by platform. For information about performing an initial configuration, see the hardware installation documentation that is provided with the original packaging of the product or go to the Product Support area of Cisco.com at http://www.cisco.com/web/psa/products/index.html.

After you have performed the initial configuration and connected the device to your network, you can configure the device by using the console port or a remote access method, such as Telnet or Secure Shell (SSH), to access the CLI or by using the configuration method provided on the device, such as Security Device Manager.

Changing the Default Settings for a Console or AUX Port

There are only two changes that you can make to a console port and an AUX port:

- Change the port speed with the **config-register 0x** command. Changing the port speed is not recommended. The well-known default speed is 9600.
- Change the behavior of the port; for example, by adding a password or changing the timeout value.

Note The AUX port on the Route Processor (RP) installed in a Cisco ASR1000 series router does not serve any useful customer purpose and should be accessed only under the advisement of a customer support representative.

Using the CLI

This section describes the following topics:

- Understanding Command Modes, page ii
- Using the Interactive Help Feature, page v
- Understanding Command Syntax, page vi
- Understanding Enable and Enable Secret Passwords, page viii
- Using the Command History Feature, page viii
- Abbreviating Commands, page ix
- Using Aliases for CLI Commands, page ix
- Using the no and default Forms of Commands, page x
- Using the debug Command, page x
- Filtering Output Using Output Modifiers, page x
- Understanding CLI Error Messages, page xi

Understanding Command Modes

The CLI command mode structure is hierarchical, and each mode supports a set of specific commands. This section describes the most common of the many modes that exist.

Table 1 lists common command modes with associated CLI prompts, access and exit methods, and a brief description of how each mode is used.

Table 1 CLI Command Modes

Command Mode	Access Method	Prompt	Exit Method	Mode Usage
User EXEC	Log in.	`Router>`	Issue the **logout** or **exit** command.	• Change terminal settings. • Perform basic tests. • Display device status.
Privileged EXEC	From user EXEC mode, issue the **enable** command.	`Router#`	Issue the **disable** command or the **exit** command to return to user EXEC mode.	• Issue **show** and **debug** commands. • Copy images to the device. • Reload the device. • Manage device configuration files. • Manage device file systems.
Global configuration	From privileged EXEC mode, issue the **configure terminal** command.	`Router(config)#`	Issue the **exit** command or the **end** command to return to privileged EXEC mode.	Configure the device.
Interface configuration	From global configuration mode, issue the **interface** command.	`Router(config-if)#`	Issue the **exit** command to return to global configuration mode or the **end** command to return to privileged EXEC mode.	Configure individual interfaces.
Line configuration	From global configuration mode, issue the **line vty** or **line console** command.	`Router(config-line)#`	Issue the **exit** command to return to global configuration mode or the **end** command to return to privileged EXEC mode.	Configure individual terminal lines.

Table 1 CLI Command Modes (continued)

Command Mode	Access Method	Prompt	Exit Method	Mode Usage
ROM monitor	From privileged EXEC mode, issue the **reload** command. Press the **Break** key during the first 60 seconds while the system is booting.	`rommon # >` The # symbol represents the line number and increments at each prompt.	Issue the **continue** command.	• Run as the default operating mode when a valid image cannot be loaded. • Access the fall-back procedure for loading an image when the device lacks a valid image and cannot be booted. • Perform password recovery when a CTRL-Break sequence is issued within 60 seconds of a power-on or reload event.
Diagnostic (available only on the Cisco ASR1000 series router)	The router boots or enters diagnostic mode in the following scenarios. When a Cisco IOS process or processes fail, in most scenarios the router will reload. • A user-configured access policy was configured using the **transport-map** command, which directed the user into diagnostic mode. • The router was accessed using an RP auxiliary port. • A break signal (**Ctrl-C**, **Ctrl-Shift-6**, or the **send break** command) was entered, and the router was configured to enter diagnostic mode when the break signal was received.	`Router(diag)#`	If a Cisco IOS process failure is the reason for entering diagnostic mode, the failure must be resolved and the router must be rebooted to exit diagnostic mode. If the router is in diagnostic mode because of a transport-map configuration, access the router through another port or using a method that is configured to connect to the Cisco IOS CLI. If the RP auxiliary port was used to access the router, use another port for access. Accessing the router through the auxiliary port is not useful for customer purposes.	• Inspect various states on the router, including the Cisco IOS state. • Replace or roll back the configuration. • Provide methods of restarting the Cisco IOS software or other processes. • Reboot hardware, such as the entire router, an RP, an ESP, a SIP, a SPA, or possibly other hardware components. • Transfer files into or off of the router using remote access methods such as FTP, TFTP, and SCP.

EXEC commands are not saved when the software reboots. Commands that you issue in a configuration mode can be saved to the startup configuration. If you save the running configuration to the startup configuration, these commands will execute when the software is rebooted. Global configuration mode is the highest level of configuration mode. From global configuration mode, you can enter a variety of other configuration modes, including protocol-specific modes.

ROM monitor mode is a separate mode that is used when the software cannot load properly. If a valid software image is not found when the software boots or if the configuration file is corrupted at startup, the software might enter ROM monitor mode. Use the question symbol (?) to view the commands that you can use while the device is in ROM monitor mode.

```
rommon 1 > ?
alias               set and display aliases command
boot                boot up an external process
confreg             configuration register utility
cont                continue executing a downloaded image
context             display the context of a loaded image
cookie              display contents of cookie PROM in hex
.
.
.
rommon 2 >
```

The following example shows how the command prompt changes to indicate a different command mode:

```
Router> enable
Router# configure terminal
Router(config)# interface ethernet 1/1
Router(config-if)# ethernet
Router(config-line)# exit
Router(config)# end
Router#
```

Note A keyboard alternative to the **end** command is Ctrl-Z.

Using the Interactive Help Feature

The CLI includes an interactive Help feature. Table 2 describes how to use the Help feature.

Table 2 CLI Interactive Help Commands

Command	Purpose
help	Provides a brief description of the help feature in any command mode.
?	Lists all commands available for a particular command mode.
*partial command***?**	Provides a list of commands that begin with the character string (no space between the command and the question mark).
partial command<**Tab**>	Completes a partial command name (no space between the command and <Tab>).
command **?**	Lists the keywords, arguments, or both associated with the command (space between the command and the question mark).
command keyword **?**	Lists the arguments that are associated with the keyword (space between the keyword and the question mark).

The following examples show how to use the help commands:

help

```
Router> help

Help may be requested at any point in a command by entering a question mark '?'.  If
nothing matches, the help list will be empty and you must backup until entering a '?'
shows the available options.

Two styles of help are provided:

1. Full help is available when you are ready to enter a command argument (e.g. 'show ?')
and describes each possible argument.

2. Partial help is provided when an abbreviated argument is entered and you want to know
what arguments match the input (e.g. 'show pr?'.)
```

?

```
Router# ?
Exec commands:
  access-enable        Create a temporary access-List entry
  access-profile       Apply user-profile to interface
  access-template      Create a temporary access-List entry
  alps                 ALPS exec commands
  archive              manage archive files
<snip>
```

***partial command*?**

```
Router(config)# zo?
zone  zone-pair
```

***partial command*<Tab>**

```
Router(config)# we<Tab> webvpn
```

***command* ?**

```
Router(config-if)# pppoe ?
  enable        Enable pppoe
  max-sessions  Maximum PPPOE sessions
```

***command keyword* ?**

```
Router(config-if)# pppoe enable ?
  group  attach a BBA group
  <cr>
```

Understanding Command Syntax

Command syntax is the format in which a command should be entered in the CLI. Commands include the name of the command, keywords, and arguments. Keywords are alphanumeric strings that are used literally. Arguments are placeholders for values that a user must supply. Keywords and arguments may be required or optional.

Specific conventions convey information about syntax and command elements. Table 3 describes these conventions.

Table 3 CLI Syntax Conventions

Symbol/Text	Function	Notes
< > (angle brackets)	Indicate that the option is an argument.	Sometimes arguments are displayed without angle brackets.
A.B.C.D.	Indicates that you must enter a dotted decimal IP address.	Angle brackets (< >) are not always used to indicate that an IP address is an argument.
WORD (all capital letters)	Indicates that you must enter one word.	Angle brackets (< >) are not always used to indicate that a WORD is an argument.
LINE (all capital letters)	Indicates that you must enter more than one word.	Angle brackets (< >) are not always used to indicate that a LINE is an argument.
<cr> (carriage return)	Indicates the end of the list of available keywords and arguments, and also indicates when keywords and arguments are optional. When <cr> is the only option, you have reached the end of the branch or the end of the command if the command has only one branch.	—

The following examples show syntax conventions:

```
Router(config)# ethernet cfm domain ?
  WORD  domain name
Router(config)# ethernet cfm domain dname ?
  level
Router(config)# ethernet cfm domain dname level ?
  <0-7>  maintenance level number
Router(config)# ethernet cfm domain dname level 7 ?
  <cr>
Router(config)# snmp-server file-transfer access-group 10 ?
  protocol  protocol options
  <cr>
Router(config)# logging host ?
  Hostname or A.B.C.D  IP address of the syslog server
  ipv6                 Configure IPv6 syslog server
Router(config)# snmp-server file-transfer access-group 10 ?
  protocol  protocol options
  <cr>
```

Understanding Enable and Enable Secret Passwords

Some privileged EXEC commands are used for actions that impact the system, and it is recommended that you set a password for these commands to prevent unauthorized use. Two types of passwords, enable (not encrypted) and enable secret (encrypted), can be set. The following commands set these passwords and are issued in global configuration mode:

- **enable** *password*
- **enable secret** *password*

Using an enable secret password is recommended because it is encrypted and more secure than the enable password. When you use an enable secret password, text is encrypted (unreadable) before it is written to the config.text file. When you use an enable password, the text is written as entered (readable) to the config.text file.

Each type of password is case sensitive, can contain from 1 to 25 uppercase and lowercase alphanumeric characters, and can start with a number. Spaces are also valid password characters; for example, "two words" is a valid password. Leading spaces are ignored, but trailing spaces are recognized.

Note Both password commands have numeric keywords that are single integer values. If you choose a number for the first character of your password followed by a space, the system will read the number as if it were the numeric keyword and not as part of your password.

When both passwords are set, the enable secret password takes precedence over the enable password.

To remove a password, use the **no** form of the commands: **no enable** *password* or **no enable secret** *password*.

For more information about password recovery procedures for Cisco products, see http://www.cisco.com/en/US/products/sw/iosswrel/ps1831/products_tech_note09186a00801746e6.shtml.

Using the Command History Feature

The CLI command history feature saves the commands you enter during a session in a command history buffer. The default number of commands saved is 10, but the number is configurable within the range of 0 to 256. This command history feature is particularly useful for recalling long or complex commands.

To change the number of commands saved in the history buffer for a terminal session, issue the **terminal history size** command:

```
Router# terminal history size num
```

A command history buffer is also available in line configuration mode with the same default and configuration options. To set the command history buffer size for a terminal session in line configuration mode, issue the **history** command:

```
Router(config-line)# history [size num]
```

To recall commands from the history buffer, use the following methods:

- Press Ctrl-P or the up arrow key—Recalls commands beginning with the most recent command. Repeat the key sequence to recall successively older commands.

- Press Ctrl-N or the down arrow key—Recalls the most recent commands in the history buffer after they have been recalled using Ctrl-P or the up arrow key. Repeat the key sequence to recall successively more recent commands.

Note The arrow keys function only on ANSI-compatible terminals such as the VT100.

- Issue the **show history** command in user EXEC or privileged EXEC mode—Lists the most recent commands that you entered. The number of commands that are displayed is determined by the setting of the **terminal history size** and **history** commands.

  The CLI command history feature is enabled by default. To disable this feature for a terminal session, issue the **terminal no history** command in user EXEC or privileged EXEC mode or the **no history** command in line configuration mode.

Abbreviating Commands

Typing a complete command name is not always required for the command to execute. The CLI recognizes an abbreviated command when the abbreviation contains enough characters to uniquely identify the command. For example, the **show version** command can be abbreviated as **sh ver**. It cannot be abbreviated as **s ver** because **s** could mean **show**, **set**, or **systat**. The **sh v** abbreviation also is not valid because the **show** command has **vrrp** as a keyword in addition to **version**. (Command and keyword examples from Cisco IOS Release 12.4(13)T.)

Using Aliases for CLI Commands

To save time and the repetition of entering the same command multiple times, you can use a command alias. An alias can be configured to do anything that can be done at the command line, but an alias cannot move between modes, type in passwords, or perform any interactive functions.

Table 4 shows the default command aliases.

Table 4 Default Command Aliases

Command Alias	Original Command
h	help
lo	logout
p	ping
s	show
u or **un**	undebug
w	where

To create a command alias, issue the **alias** command in global configuration mode. The syntax of the command is **alias** *mode command-alias original-command*. Following are some examples:

- Router(config)# **alias exec prt partition**—privileged EXEC mode
- Router(config)# **alias configure sb source-bridge**—global configuration mode
- Router(config)# **alias interface rl rate-limit**—interface configuration mode

To view both default and user-created aliases, issue the **show alias** command.

For more information about the **alias** command, see http://www.cisco.com/en/US/docs/ios/fundamentals/command/reference/cf_book.html.

Using the no and default Forms of Commands

Most configuration commands have a **no** form that is used to reset a command to its default value or disable a feature or function. For example, the **ip routing** command is enabled by default. To disable this command, you would issue the **no ip routing** command. To re-enable IP routing, you would issue the **ip routing** command.

Configuration commands may also have a **default** form, which returns the command settings to their default values. For commands that are disabled by default, using the **default** form has the same effect as using the **no** form of the command. For commands that are enabled by default and have default settings, the **default** form enables the command and returns the settings to their default values.

The **no** and **default** forms of commands are described in the command pages of command references.

Using the debug Command

A **debug** command produces extensive output that helps you troubleshoot problems in your network. These commands are available for many features and functions within Cisco IOS and Cisco IOS XE software. Some **debug** commands are **debug all**, **debug aaa accounting**, and **debug mpls packets**. To use **debug** commands during a Telnet session with a device, you must first enter the **terminal monitor** command. To turn off debugging completely, you must enter the **undebug all** command.

For more information about **debug** commands, see the *Cisco IOS Debug Command Reference* at http://www.cisco.com/en/US/docs/ios/debug/command/reference/db_book.html.

Caution Debugging is a high priority and high CPU utilization process that can render your device unusable. Use **debug** commands only to troubleshoot specific problems. The best times to run debugging are during periods of low network traffic and when few users are interacting with the network. Debugging during these periods decreases the likelihood that the **debug** command processing overhead will affect network performance or user access or response times.

Filtering Output Using Output Modifiers

Many commands produce lengthy output that may use several screens to display. Using output modifiers, you can filter this output to show only the information that you want to see.

Three output modifiers are available and are described as follows:

- **begin** *regular expression*—Displays the first line in which a match of the regular expression is found and all lines that follow.
- **include** *regular expression*—Displays all lines in which a match of the regular expression is found.
- **exclude** *regular expression*—Displays all lines except those in which a match of the regular expression is found.

To use one of these output modifiers, type the command followed by the pipe symbol (|), the modifier, and the regular expression that you want to search for or filter. A regular expression is a case-sensitive alphanumeric pattern. It can be a single character or number, a phrase, or a more complex string.

The following example illustrates how to filter output of the **show interface** command to display only lines that include the expression "protocol."

```
Router# show interface | include protocol

FastEthernet0/0 is up, line protocol is up
Serial4/0 is up, line protocol is up
Serial4/1 is up, line protocol is up
Serial4/2 is administratively down, line protocol is down
Serial4/3 is administratively down, line protocol is down
```

Understanding CLI Error Messages

You may encounter some error messages while using the CLI. Table 5 shows the common CLI error messages.

Table 5 Common CLI Error Messages

Error Message	Meaning	How to Get Help
% Ambiguous command: "show con"	You did not enter enough characters for the command to be recognized.	Reenter the command followed by a space and a question mark (?). The keywords that you are allowed to enter for the command appear.
% Incomplete command.	You did not enter all the keywords or values required by the command.	Reenter the command followed by a space and a question mark (?). The keywords that you are allowed to enter for the command appear.
% Invalid input detected at "^" marker.	You entered the command incorrectly. The caret (^) marks the point of the error.	Enter a question mark (?) to display all the commands that are available in this command mode. The keywords that you are allowed to enter for the command appear.

For more system error messages, see the following documents:

- *Cisco IOS Release 12.2SR System Message Guide*
- *Cisco IOS System Messages, Volume 1 of 2* (Cisco IOS Release 12.4)
- *Cisco IOS System Messages, Volume 2 of 2* (Cisco IOS Release 12.4)

Saving Changes to a Configuration

To save changes that you made to the configuration of a device, you must issue the **copy running-config startup-config** command or the **copy system:running-config nvram:startup-config** command. When you issue these commands, the configuration changes that you made are saved to the startup configuration and saved when the software reloads or power to the device is turned off or interrupted. The following example shows the syntax of the **copy running-config startup-config** command:

```
Router# copy running-config startup-config
Destination filename [startup-config]?
```

You press Enter to accept the startup-config filename (the default), or type a new filename and then press Enter to accept that name. The following output is displayed indicating that the configuration was saved:

```
Building configuration...
[OK]
Router#
```

On most platforms, the configuration is saved to NVRAM. On platforms with a Class A flash file system, the configuration is saved to the location specified by the CONFIG_FILE environment variable. The CONFIG_FILE variable defaults to NVRAM.

Additional Information

- "Using the Cisco IOS Command-Line Interface" section of the *Cisco IOS Configuration Fundamentals Configuration Guide*:

  http://www.cisco.com/en/US/docs/ios/fundamentals/configuration/guide/cf_cli-basics.html

  or

  "Using Cisco IOS XE Software" chapter of the *Cisco ASR1000 Series Aggregation Services Routers Software Configuration Guide*:

  http://www.cisco.com/en/US/docs/routers/asr1000/configuration/guide/chassis/using_cli.html
- Cisco Product Support Resources

  http://www.cisco.com/web/psa/products/index.html
- Support area on Cisco.com (also search for documentation by task or product)

  http://www.cisco.com/en/US/support/index.html
- *White Paper: Cisco IOS Reference Guide*

  http://www.cisco.com/en/US/products/sw/iosswrel/ps1828/products_white_paper09186a008018305e.shtml
- Software Download Center (downloads; tools; licensing, registration, advisory, and general information) (requires Cisco.com User ID and password)

  http://www.cisco.com/kobayashi/sw-center/
- Error Message Decoder, a tool to help you research and resolve error messages for Cisco IOS software

  http://www.cisco.com/pcgi-bin/Support/Errordecoder/index.cgi

- Command Lookup Tool, a tool to help you find detailed descriptions of Cisco IOS commands (requires Cisco.com user ID and password)

  http://tools.cisco.com/Support/CLILookup

- Output Interpreter, a troubleshooting tool that analyzes command output of supported **show** commands

  https://www.cisco.com/pcgi-bin/Support/OutputInterpreter/home.pl\

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Virtual LANs

Virtual LANS Features Roadmap

This roadmap lists the features documented in the *Virtual LANs* modules in which they appear.

Roadmap History

This roadmap was first published April 20, 2006 and last updated on April 20, 2006.

Features and Release Support

Table 1 lists Virtual LANs feature support for the following Cisco IOS software release trains:

- Cisco IOS Releases 12.0, 12.1, 12.2, 12.3, and 12.3T

Only features that were introduced or modified in Cisco IOS Release 12.0 (1) or a later release appear in the table. *Not all features may be supported in your Cisco IOS software release*.

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 1 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

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Table 1 Supported Network Address Translation Features

Release	Feature Name	Feature Description	Where Documented
Cisco IOS Releases 12.0, 12.1, 12.2, 12.3, and 12.3T			
12.0(7)XE 12.1(5)T 12.2(2)DD 12.2(4)B 12.2(8)T 12.2(13)T	VLAN Range	Using the VLAN Range feature, you can group VLAN subinterfaces together so that any command entered in a group applies to every subinterface within the group. This capability simplifies configurations and reduces command parsing.	Configuring Routing Between VLANs • Configuring a Range of VLAN Subinterfaces, page 323
	Configuring Routing Between VLANs with IEEE 802.1Q Encapsulation	The IEEE 802.1Q protocol is used to interconnect multiple switches and routers, and for defining VLAN topologies. The IEEE 802.1Q standard is extremely restrictive to untagged frames. The standard provides only a per-port VLANs solution for untagged frames. For example, assigning untagged frames to VLANs takes into consideration only the port from which they have been received. Each port has a parameter called a *permanent virtual identification* (Native VLAN) that specifies the VLAN assigned to receive untagged frames.	Configuring Routing Between VLANs • Configuring Routing Between VLANs with IEEE 802.1Q Encapsulation
	Configuring Routing Between VLANs with Inter-Switch Link Encapsulation	ISL is a Cisco protocol for interconnecting multiple switches and maintaining VLAN information as traffic goes between switches. ISL provides VLAN capabilities while maintaining full wire speed performance on Fast Ethernet links in full- or half-duplex mode. ISL operates in a point-to-point environment and will support up to 1000 VLANs. You can define virtually as many logical networks as are necessary for your environment.	Configuring Routing Between VLANs • Configuring Routing Between VLANs with Inter-Switch Link Encapsulation
	Configuring Routing Between VLANs with IEEE 802.10 Encapsulation	AppleTalk can be routed over VLAN subinterfaces using the ISL or IEEE 802.10 VLANs feature that provides full-feature Cisco IOS software AppleTalk support on a per-VLAN basis, allowing standard AppleTalk capabilities to be configured on VLANs.	Configuring Routing Between VLANs • Configuring Routing Between VLANs with IEEE 802.10 Encapsulation

Table 1 Supported Network Address Translation Features (continued)

Release	Feature Name	Feature Description	Where Documented
12.3(8)T4	Cisco HWIC-4ESW and HWIC-D-9ESW EtherSwitch Interface Cards	Cisco EtherSwitch HWICs are 10/100BASE-T Layer 2 Ethernet switches with Layer 3 routing capability. (Layer 3 routing is forwarded to the host and is not actually performed at the switch.) Traffic between different VLANs on a switch is routed through the router platform. Any one port on a Cisco EtherSwitch HWIC may be configured as a stacking port to link to another Cisco EtherSwitch HWIC or EtherSwitch network module in the same system. An optional power module can also be added to provide inline power for IP telephones. The HWIC-D-9ESW HWIC requires a double-wide card slot.	Cisco HWIC-4ESW and HWIC-D-9ESW EtherSwitch Interface Cards
12.2(2)XT 12.2(8)T 12.2(15)ZJ 12.3(4)T	EtherSwitch Module	The EtherSwitch network module is supported on Cisco 2600 series, Cisco 3600 series, and Cisco 3700 series routers. The EtherSwitch network module is a modular, high-density voice network module that provides Layer 2 switching across Ethernet ports. The EtherSwitch network module has sixteen 10/100 switched Ethernet ports with integrated inline power and QoS features that are designed to extend Cisco AVVID-based voice-over-IP (VoIP) networks to small branch offices.	EtherSwitch Network Module
12.3(2)XC	Managed VLAN Switch	The Managed LAN Switch feature enables the control of the four switch ports in Cisco 831, 836, and 837 routers. Each switch port is associated with a Fast Ethernet interface.	Managed LAN Switch
12.3(7)T 12.3(7)XI1	IEEE 802.1Q-in-Q VLAN Tag Termination	Encapsulating IEEE 802.1Q VLAN tags within 802.1Q enables service providers to use a single VLAN to support customers who have multiple VLANs. The IEEE 802.1Q-in-Q VLAN Tag Termination feature on the subinterface level preserves VLAN IDs and keeps traffic in different customer VLANs segregated.	Configuring Routing Between VLANs • Configuring IEEE 802.1Q-in-Q VLAN Tag Termination, page 350

Table 1 Supported Network Address Translation Features (continued)

Release	Feature Name	Feature Description	Where Documented
Cisco IOS Releases 12.2SR			
12.2(33)SRB	cGVRP	The Compact (c) Generic Attribute Registration Protocol (GARP) VLAN Registration Protocol (GVRP) feature reduces CPU time for transmittal of 4094 VLAN states on a port. GVRP enables automatic configuration of switches in a VLAN network allowing network devices to dynamically exchange VLAN configuration information with other devices. GVRP is based on GARP which defines procedures for registering and deregistering attributes with each other. It eliminates unnecessary network traffic by preventing attempts to transmit information to unregistered users. GVRP is defined in IEEE 802.1Q.	cGVRP

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Configuring Routing Between VLANs

First Published: March 15, 2006
Last Updated: October 10, 2008

This module provides an overview of VLANs. It describes the encapsulation protocols used for routing between VLANs and provides some basic information about designing VLANs. This module contains tasks for configuring routing between VLANS.

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for Routing Between VLANs" section on page 71.

Finding Support Information for Platforms and Cisco IOS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS software image support. Access Cisco Feature Navigator at http://www.cisco.com/go/fn. You must have an account on Cisco.com. If you do not have an account or have forgotten your username or password, click **Cancel** at the login dialog box and follow the instructions that appear.

Contents

- Information About Routing Between VLANs, page 2
- How to Configure Routing Between VLANS, page 12
- Configuration Examples for Configuring Routing Between VLANs, page 52
- Additional References, page 70
- Feature Information for Routing Between VLANs, page 71

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Information About Routing Between VLANs

This module describes routing between VLANs. It contains the following sections:

- Virtual Local Area Network Definition, page 2
- VLAN Performance, page 4
- VLAN Colors, page 8
- Implementing VLANS, page 9
- Communication Between VLANs, page 9
- VLAN Interoperability, page 11
- Designing Switched VLANs, page 12

Virtual Local Area Network Definition

A virtual local area network (VLAN) is a switched network that is logically segmented on an organizational basis, by functions, project teams, or applications rather than on a physical or geographical basis. For example, all workstations and servers used by a particular workgroup team can be connected to the same VLAN, regardless of their physical connections to the network or the fact that they might be intermingled with other teams. Reconfiguration of the network can be done through software rather than by physically unplugging and moving devices or wires.

A VLAN can be thought of as a broadcast domain that exists within a defined set of switches. A VLAN consists of a number of end systems, either hosts or network equipment (such as bridges and routers), connected by a single bridging domain. The bridging domain is supported on various pieces of network equipment; for example, LAN switches that operate bridging protocols between them with a separate bridge group for each VLAN.

VLANs are created to provide the segmentation services traditionally provided by routers in LAN configurations. VLANs address scalability, security, and network management. Routers in VLAN topologies provide broadcast filtering, security, address summarization, and traffic flow management. None of the switches within the defined group will bridge any frames, not even broadcast frames, between two VLANs. Several key issues described in the following sections need to be considered when designing and building switched LAN internetworks:

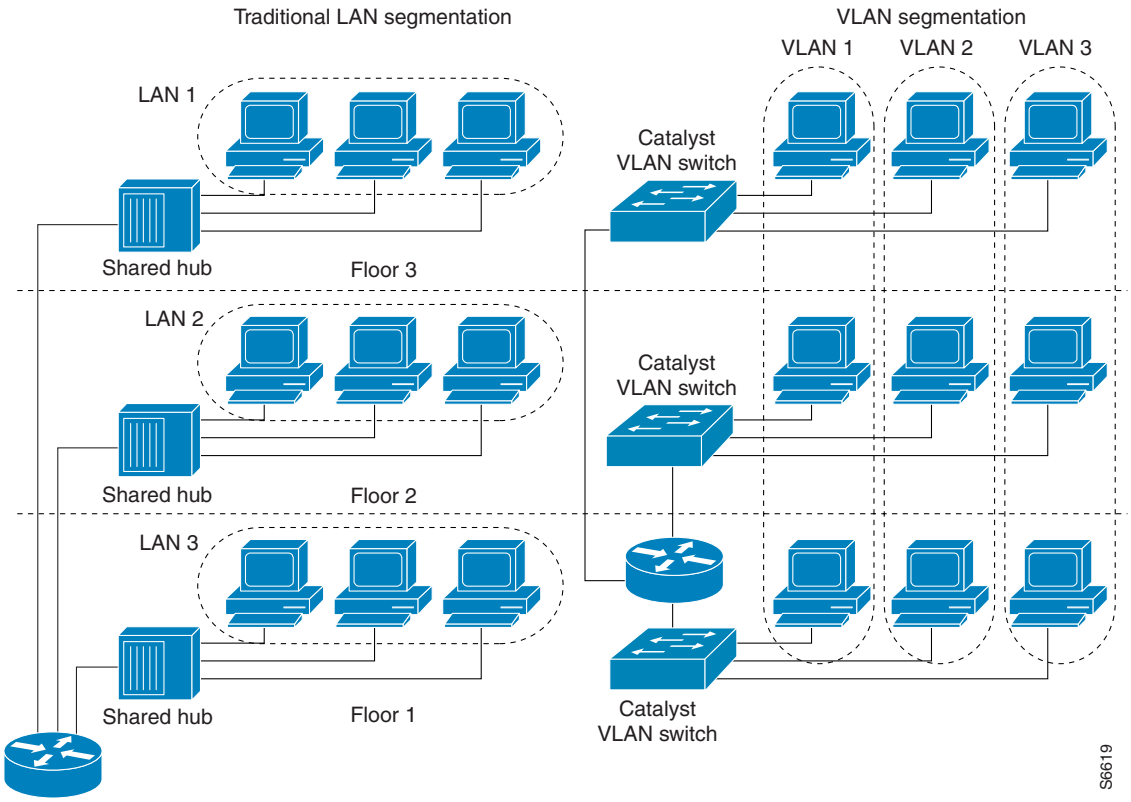
- LAN Segmentation, page 3
- Security, page 3
- Broadcast Control, page 4
- VLAN Performance, page 4
- Network Management, page 4
- Network Monitoring Using SNMP, page 4
- Communication Between VLANs
- Relaying Function, page 4
- Native VLAN, page 6
- PVST+, page 7
- Ingress and Egress Rules, page 8
- Integrated Routing and Bridging, page 8

LAN Segmentation

VLANs allow logical network topologies to overlay the physical switched infrastructure such that any arbitrary collection of LAN ports can be combined into an autonomous user group or community of interest. The technology logically segments the network into separate Layer 2 broadcast domains whereby packets are switched between ports designated to be within the same VLAN. By containing traffic originating on a particular LAN only to other LANs in the same VLAN, switched virtual networks avoid wasting bandwidth, a drawback inherent to traditional bridged and switched networks in which packets are often forwarded to LANs with no need for them. Implementation of VLANs also improves scalability, particularly in LAN environments that support broadcast- or multicast-intensive protocols and applications that flood packets throughout the network.

Figure 73 illustrates the difference between traditional physical LAN segmentation and logical VLAN segmentation.

Figure 73 LAN Segmentation and VLAN Segmentation



Security

VLANs improve security by isolating groups. High-security users can be grouped into a VLAN, possibly on the same physical segment, and no users outside that VLAN can communicate with them.

Broadcast Control

Just as switches isolate collision domains for attached hosts and only forward appropriate traffic out a particular port, VLANs provide complete isolation between VLANs. A VLAN is a bridging domain, and all broadcast and multicast traffic is contained within it.

VLAN Performance

The logical grouping of users allows an accounting group to make intensive use of a networked accounting system assigned to a VLAN that contains just that accounting group and its servers. That group's work will not affect other users. The VLAN configuration improves general network performance by not slowing down other users sharing the network.

Network Management

The logical grouping of users allows easier network management. It is not necessary to pull cables to move a user from one network to another. Adds, moves, and changes are achieved by configuring a port into the appropriate VLAN.

Network Monitoring Using SNMP

SNMP support has been added to provide mib-2 interfaces sparse table support for Fast Ethernet subinterfaces. Monitor your VLAN subinterface using the **show vlans** EXEC command. For more information on configuring SNMP on your Cisco network device or enabling an SNMP agent for remote access, refer to the "Configuring SNMP" chapter in the *Cisco IOS Configuration Fundamentals Configuration Guide*.

Communication Between VLANs

Communication between VLANs is accomplished through routing, and the traditional security and filtering functions of the router can be used. Cisco IOS software provides network services such as security filtering, quality of service (QoS), and accounting on a per-VLAN basis. As switched networks evolve to distributed VLANs, Cisco IOS software provides key inter-VLAN communications and allows the network to scale.

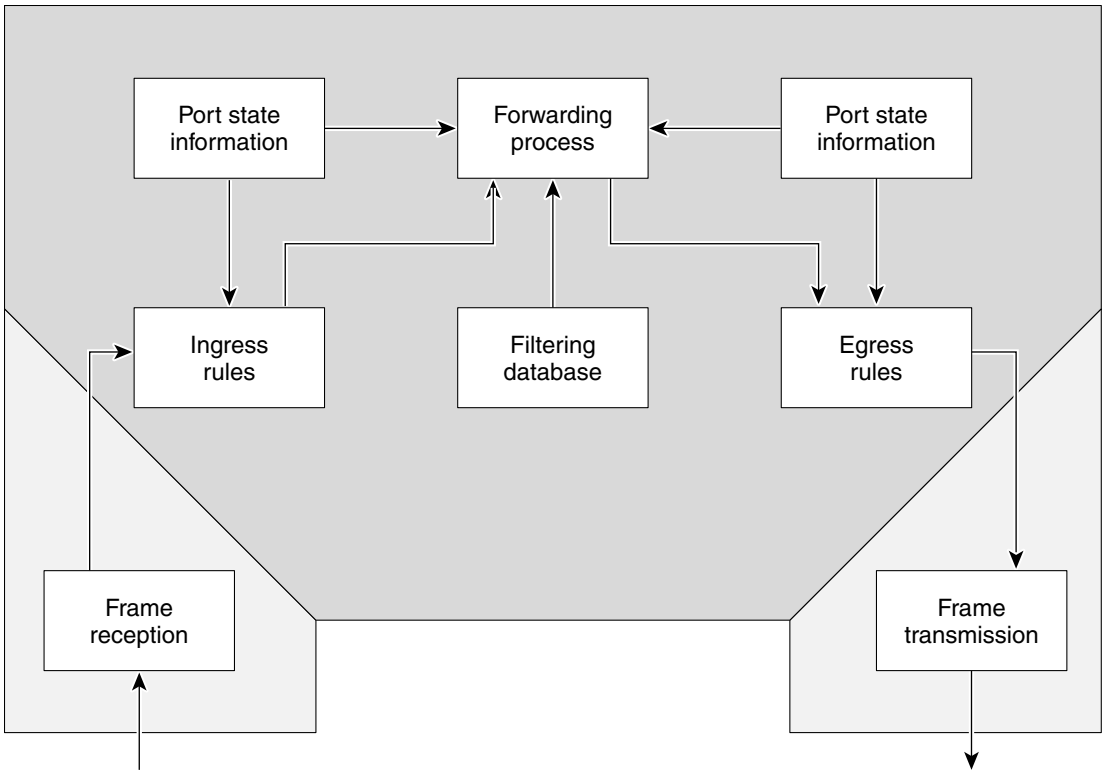
Before Cisco IOS Release 12.2, Cisco IOS support for interfaces that have 802.1Q encapsulation configured is IP, IP multicast, and IPX routing between respective VLANs represented as subinterfaces on a link. New functionality has been added in IEEE 802.1Q support for bridging on those interfaces and the capability to configure and use integrated routing and bridging (IRB).

Relaying Function

The relaying function level, as displayed in Figure 74, is the lowest level in the architectural model described in the IEEE 802.1Q standard and presents three types of rules:

- Ingress rules—Rules relevant to the classification of received frames belonging to a VLAN.
- Forwarding rules between ports—Rules decide whether to filter or forward the frame.
- Egress rules (output of frames from the switch)—Rules decide if the frame must be sent tagged or untagged.

Figure 74 Relaying Function

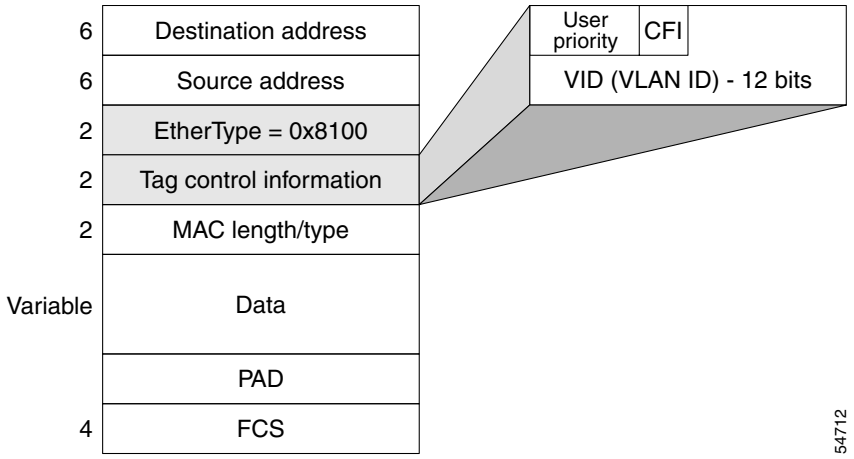


The Tagging Scheme

Figure 75 shows the tagging scheme proposed by the 802.3ac standard, that is, the addition of the four octets after the source MAC address. Their presence is indicated by a particular value of the EtherType field (called TPID), which has been fixed to be equal to 0x8100. When a frame has the EtherType equal to 0x8100, this frame carries the tag IEEE 802.1Q/802.1p. The tag is stored in the following two octets and it contains 3 bits of user priority, 1 bit of Canonical Format Identifier (CFI), and 12 bits of VLAN ID (VID). The 3 bits of user priority are used by the 802.1p standard; the CFI is used for compatibility reasons between Ethernet-type networks and Token Ring-type networks. The VID is the identification of the VLAN, which is basically used by the 802.1Q standard; being on 12 bits, it allows the identification of 4096 VLANs.

After the two octets of TPID and the two octets of the Tag Control Information field there are two octets that originally would have been located after the Source Address field where there is the TPID. They contain either the MAC length in the case of IEEE 802.3 or the EtherType in the case of Ethernet version 2.

Figure 75 Tagging Scheme

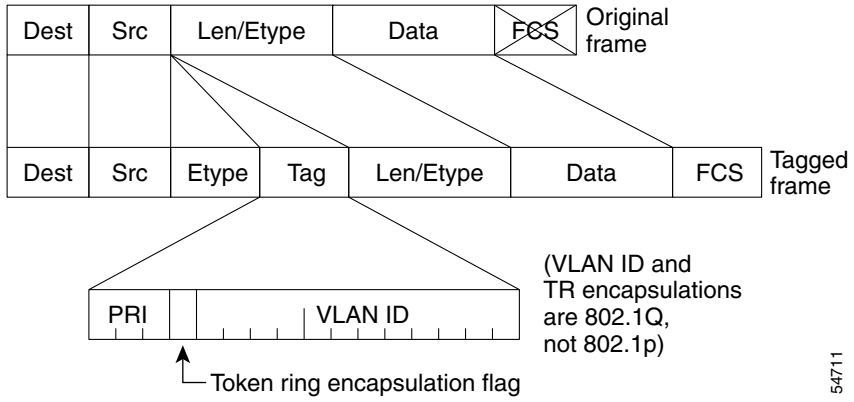


The EtherType and VLAN ID are inserted after the MAC source address, but before the original Ethertype/Length or Logical Link Control (LLC). The 1-bit CFI included a T-R Encapsulation bit so that Token Ring frames can be carried across Ethernet backbones without using 802.1H translation.

Frame Control Sequence Recomputation

Figure 76 shows how adding a tag in a frame recomputes the Frame Control Sequence. 802.1p and 802.1Q share the same tag.

Figure 76 Adding a Tag Recomputes the Frame Control Sequence

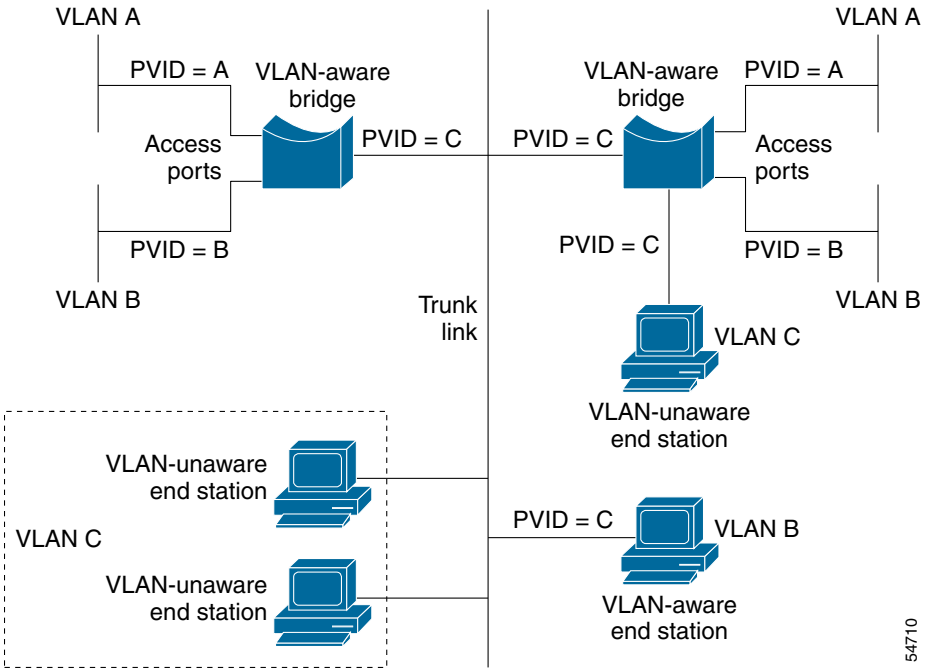


Native VLAN

Each physical port has a parameter called PVID. Every 802.1Q port is assigned a PVID value that is of its native VLAN ID (default is VLAN 1). All untagged frames are assigned to the LAN specified in the PVID parameter. When a tagged frame is received by a port, the tag is respected. If the frame is untagged, the value contained in the PVID is considered as a tag. Because the frame is untagged and the PVID is tagged to allow the coexistence, as shown in Figure 77, on the same pieces of cable of VLAN-aware bridge/stations and of VLAN-unaware bridges/stations. Consider, for example, the two stations

connected to the central trunk link in the lower part of Figure 77. They are VLAN-unaware and they will be associated to the VLAN C, because the PVIDs of the VLAN-aware bridges are equal to VLAN C. Because the VLAN-unaware stations will send only untagged frames, when the VLAN-aware bridge devices receive these untagged frames they will assign them to VLAN C.

Figure 77 Native VLAN



PVST+

PVST+ provides support for 802.1Q trunks and the mapping of multiple spanning trees to the single spanning tree of 802.1Q switches.

The PVST+ architecture distinguishes three types of regions:

- A PVST region
- A PVST+ region
- A MST region

Each region consists of a homogenous type of switch. A PVST region can be connected to a PVST+ region by connecting two ISL ports. Similarly, a PVST+ region can be connected to an MST region by connecting two 802.1Q ports.

At the boundary between a PVST region and a PVST+ region the mapping of spanning trees is one-to-one. At the boundary between a MST region and a PVST+ region, the ST in the MST region maps to one PVST in the PVST+ region. The one it maps to is called the common spanning tree (CST). The default CST is the PVST of VLAN 1 (Native VLAN).

All PVSTs, except for the CST, are tunneled through the MST region. Tunneling means that bridge protocol data units (BPDUs) are flooded through the MST region along the single spanning tree present in the MST region.

Ingress and Egress Rules

The BPDU transmission on the 802.1Q port of a PVST+ router will be implemented in compliance with the following rules:

- The CST BPDU (of VLAN 1, by default) is sent to the IEEE address.
- All the other BPDUs are sent to Shared Spanning Tree Protocol (SSTP)-Address and encapsulated with Logical Link Control-Subnetwork Access Protocol (LLC-SNAP) header.
- The BPDU of the CST and BPDU of the VLAN equal to the PVID of the 802.1Q trunk are sent untagged.
- All other BPDUs are sent tagged with the VLAN ID.
- The CST BPDU is also sent to the SSTP address.
- Each SSTP-addressed BPDU is also tailed by a Tag-Length-Value for the PVID checking.

The BPDU reception on the 802.1Q port of a PVST+ router will follow these rules:

- All untagged IEEE addressed BPDUs must be received on the PVID of the 802.1Q port.
- The IEEE addressed BPDUs whose VLAN ID matches the Native VLAN are processed by CST.
- All the other IEEE addressed BPDUs whose VLAN ID does not match the Native VLAN and whose port type is not of 802.1Q are processed by the spanning tree of that particular VLAN ID.
- The SSTP addressed BPDU whose VLAN ID is not equal to the TLV are dropped and the ports are blocked for inconsistency.
- All the other SSTP addressed BPDUs whose VLAN ID is not equal to the Native VLAN are processed by the spanning tree of that particular VLAN ID.
- The SSTP addressed BPDUs whose VLAN ID is equal to the Native VLAN are dropped. It is used for consistency checking.

Integrated Routing and Bridging

IRB enables a user to route a given protocol between routed interfaces and bridge groups or route a given protocol between the bridge groups. Integrated routing and bridging is supported on the following protocols:

- IP
- IPX
- AppleTalk

VLAN Colors

VLAN switching is accomplished through *frame tagging* where traffic originating and contained within a particular virtual topology carries a unique VLAN ID as it traverses a common backbone or trunk link. The VLAN ID enables VLAN switching devices to make intelligent forwarding decisions based on the embedded VLAN ID. Each VLAN is differentiated by a *color*, or VLAN identifier. The unique VLAN ID determines the *frame coloring* for the VLAN. Packets originating and contained within a particular VLAN carry the identifier that uniquely defines that VLAN (by the VLAN ID).

The VLAN ID allows VLAN switches and routers to selectively forward packets to ports with the same VLAN ID. The switch that receives the frame from the source station inserts the VLAN ID and the packet is switched onto the shared backbone network. When the frame exits the switched LAN, a switch

strips the header and forwards the frame to interfaces that match the VLAN color. If you are using a Cisco network management product such as VlanDirector, you can actually color code the VLANs and monitor VLAN graphically.

Implementing VLANS

Network managers can logically group networks that span all major topologies, including high-speed technologies such as, ATM, FDDI, and Fast Ethernet. By creating virtual LANs, system and network administrators can control traffic patterns and react quickly to relocations and keep up with constant changes in the network due to moving requirements and node relocation just by changing the VLAN member list in the router configuration. They can add, remove, or move devices or make other changes to network configuration using software to make the changes.

Issues regarding creating VLANs should have been addressed when you developed your network design. Issues to consider include the following:

- Scalability
- Performance improvements
- Security
- Network additions, moves, and changes

Communication Between VLANs

Cisco IOS software provides full-feature routing at Layer 3 and translation at Layer 2 between VLANs. Five different protocols are available for routing between VLANs:

- Inter-Switch Link Protocol, page 9
- IEEE 802.10 Protocol, page 10
- IEEE 802.1Q Protocol, page 10
- ATM LANE Protocol, page 10
- ATM LANE Fast Simple Server Replication Protocol, page 10

All five of these technologies are based on OSI Layer 2 bridge multiplexing mechanisms.

Inter-Switch Link Protocol

The Inter-Switch Link (ISL) protocol is used to interconnect two VLAN-capable Ethernet, Fast Ethernet, or Gigabit Ethernet devices, such as the Catalyst 3000 or 5000 switches and Cisco 7500 routers. The ISL protocol is a packet-tagging protocol that contains a standard Ethernet frame and the VLAN information associated with that frame. The packets on the ISL link contain a standard Ethernet, FDDI, or Token Ring frame and the VLAN information associated with that frame. ISL is currently supported only over Fast Ethernet links, but a single ISL link, or trunk, can carry different protocols from multiple VLANs.

Procedures for configuring ISL and Token Ring ISL (TRISL) features are provided in "Configuring Routing Between VLANs with Inter-Switch Link Encapsulation" section on page 15.

IEEE 802.10 Protocol

The IEEE 802.10 protocol provides connectivity between VLANs. Originally developed to address the growing need for security within shared LAN/MAN environments, it incorporates authentication and encryption techniques to ensure data confidentiality and integrity throughout the network. Additionally, by functioning at Layer 2, it is well suited to high-throughput, low-latency switching environments. The IEEE 802.10 protocol can run over any LAN or HDLC serial interface.

Procedures for configuring routing between VLANs with IEEE 802.10 encapsulation are provided in the "Configuring Routing Between VLANs with IEEE 802.10 Encapsulation" section on page 31.

IEEE 802.1Q Protocol

The IEEE 802.1Q protocol is used to interconnect multiple switches and routers, and for defining VLAN topologies. Cisco currently supports IEEE 802.1Q for Fast Ethernet and Gigabit Ethernet interfaces.

Note Cisco does not support IEEE 802.1Q encapsulation for Ethernet interfaces.

Procedures for configuring routing between VLANs with IEEE 802.1Q encapsulation are provided in the "Configuring Routing Between VLANs with IEEE 802.1Q Encapsulation" section on page 34.

ATM LANE Protocol

The ATM LAN Emulation (LANE) protocol provides a way for legacy LAN users to take advantage of ATM benefits without requiring modifications to end-station hardware or software. LANE emulates a broadcast environment like IEEE 802.3 Ethernet on top of an ATM network that is a point-to-point environment.

LANE makes ATM function like a LAN. LANE allows standard LAN drivers like NDIS and ODI to be used. The virtual LAN is transparent to applications. Applications can use normal LAN functions without the underlying complexities of the ATM implementation. For example, a station can send broadcasts and multicasts, even though ATM is defined as a point-to-point technology and does not support any-to-any services.

To accomplish this, special low-level software is implemented on an ATM client workstation, called the LAN Emulation Client (LEC). The client software communicates with a central control point called a LAN Emulation Server (LES). A broadcast and unknown server (BUS) acts as a central point to distribute broadcasts and multicasts. The LAN Emulation Configuration Server (LECS) holds a database of LECs and the ELANs they belong to. The database is maintained by a network administrator.

These protocols are described in detail in the *Cisco Internetworking Design Guide*.

ATM LANE Fast Simple Server Replication Protocol

To improve the ATM LANE Simple Server Replication Protocol (SSRP), Cisco introduced the ATM LANE Fast Simple Server Replication Protocol (FSSRP). FSSRP differs from LANE SSRP in that all configured LANE servers of an ELAN are always active. FSSRP-enabled LANE clients have virtual circuits (VCs) established to a maximum of four LANE servers and BUSs at one time. If a single LANE server goes down, the LANE client quickly switches over to the next LANE server and BUS, resulting in no data or LE ARP table entry loss and no extraneous signalling.

The FSSRP feature improves upon SSRP such that LANE server and BUS switchover for LANE clients is immediate. With SSRP, a LANE server would go down, and depending on the network load, it may have taken considerable time for the LANE client to come back up joined to the correct LANE server and BUS. In addition to going down with SSRP, the LANE client would do the following:

- Clear out its data direct VCs
- Clear out its LE ARP entries
- Cause substantial signalling activity and data loss

FSSRP was designed to alleviate these problems with the LANE client. With FSSRP, each LANE client is simultaneously joined to up to four LANE servers and BUSs. The concept of the master LANE server and BUS is maintained; the LANE client uses the master LANE server when it needs LANE server BUS services. However, the difference between SSRP and FSSRP is that if and when the master LANE server goes down, the LANE client is already connected to multiple backup LANE servers and BUSs. The LANE client simply uses the next backup LANE server and BUS as the master LANE server and BUS.

VLAN Interoperability

Cisco IOS features bring added benefits to the VLAN technology. Enhancements to ISL, IEEE 802.10, and ATM LANE implementations enable routing of all major protocols between VLANs. These enhancements allow users to create more robust networks incorporating VLAN configurations by providing communications capabilities between VLANs.

Inter-VLAN Communications

The Cisco IOS supports full routing of several protocols over ISL and ATM LANE VLANs. IP, Novell IPX, and AppleTalk routing are supported over IEEE 802.10 VLANs. Standard routing attributes such as network advertisements, secondaries, and help addresses are applicable, and VLAN routing is fast switched. Table 39 shows protocols supported for each VLAN encapsulation format and corresponding Cisco IOS software releases.

Table 39 Inter-VLAN Routing Protocol Support

Protocol	ISL	ATM LANE	IEEE 802.10
IP	Release 11.1	Release 10.3	Release 11.1
Novell IPX (default encapsulation)	Release 11.1	Release 10.3	Release 11.1
Novell IPX (configurable encapsulation)	Release 11.3	Release 10.3	Release 11.3
AppleTalk Phase II	Release 11.3	Release 10.3	—
DECnet	Release 11.3	Release 11.0	—
Banyan VINES	Release 11.3	Release 11.2	—
XNS	Release 11.3	Release 11.2	—
CLNS	Release 12.1	—	—
IS-IS	Release 12.1	—	—

VLAN Translation

VLAN translation refers to the ability of the Cisco IOS software to translate between different VLANs or between VLAN and non-VLAN encapsulating interfaces at Layer 2. Translation is typically used for selective inter-VLAN switching of nonroutable protocols and to extend a single VLAN topology across hybrid switching environments. It is also possible to bridge VLANs on the main interface; the VLAN encapsulating header is preserved. Topology changes in one VLAN domain do not affect a different VLAN.

Designing Switched VLANs

By the time you are ready to configure routing between VLANs, you will have already defined them through the switches in your network. Issues related to network design and VLAN definition should be addressed during your network design. Refer to the *Cisco Internetworking Design Guide* and appropriate switch documentation for information on these topics:

- Sharing resources between VLANs
- Load balancing
- Redundant links
- Addressing
- Segmenting networks with VLANs—Segmenting the network into broadcast groups improves network security. Use router access lists based on station addresses, application types, and protocol types.
- Routers and their role in switched networks—In switched networks, routers perform broadcast management, route processing, and distribution, and provide communication between VLANs. Routers provide VLAN access to shared resources and connect to other parts of the network that are either logically segmented with the more traditional subnet approach or require access to remote sites across wide-area links.

How to Configure Routing Between VLANS

This section contains the following configuration procedure groups:

- Configuring a VLAN Range, page 12
- Configuring Routing Between VLANs with Inter-Switch Link Encapsulation
- Configuring Routing Between VLANs with IEEE 802.10 Encapsulation
- Configuring Routing Between VLANs with IEEE 802.1Q Encapsulation
- Configuring IEEE 802.1Q-in-Q VLAN Tag Termination

Configuring a VLAN Range

Using the VLAN Range feature, you can group VLAN subinterfaces together so that any command entered in a group applies to every subinterface within the group. This capability simplifies configurations and reduces command parsing.

Restrictions

- Each command you enter while you are in interface configuration mode with the **interface range** command is executed as it is entered. The commands are not batched together for execution after you exit interface configuration mode. If you exit interface configuration mode while the commands are being executed, some commands might not be executed on some interfaces in the range. Wait until the command prompt reappears before exiting interface configuration mode.
- The **no interface range** command is not supported. You must delete individual subinterfaces to delete a range.

Supported Platforms

For Cisco IOS Release 12.2(13)T, the following platforms are supported:

- Cisco 6400 series
- Cisco 7200 series
- Cisco 7401 ASR router

Benefits

The VLAN Range feature provides the following benefits:

Simultaneous Configurations

Identical commands can be entered once for a range of subinterfaces, rather than being entered separately for each subinterface.

Overlapping Range Configurations

Overlapping ranges of subinterfaces can be configured.

Customized Subinterfaces

Individual subinterfaces within a range can be customized or deleted.

Configuring a Range of VLAN Subinterfaces

Use the following commands to configure a range of VLAN subinterfaces.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface range** {{**ethernet** | **fastethernet** | **gigabitethernet** | **atm**} *slot*/*interface*.*subinterface* **-** {{**ethernet** | **fastethernet** | **gigabitethernet** | **atm**}*slot*/*interface*.*subinterface*}]
4. **encapsulation dot1Q** *vlan-id*
5. **no shutdown**
6. exit
7. show running-config

8. show interfaces

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface range** {{**ethernet** | **fastethernet** | **gigabitethernet** | **atm**} *slot*/*interface*.*subinterface* **-** {{**ethernet** | **fastethernet** | **gigabitethernet** | **atm**}*slot*/*interface*.*subinterface*} **Example:** `Router(config)# interface range fastethernet5/1.1 - fastethernet5/1.4`	Selects the range of subinterfaces to be configured. **Note** The spaces around the dash are required. For example, the command **interface range fastethernet 1 - 5** is valid; the command **interface range fastethernet 1-5** is not valid.
Step 4	**encapsulation dot1Q** *vlan-id* **Example:** `Router(config-if)# encapsulation dot1Q 301`	Applies a unique VLAN ID to each subinterface within the range. • *vlan-id*—Virtual LAN identifier. The allowed range is from 1 to 4095. • The VLAN ID specified by the *vlan-id* argument is applied to the first subinterface in the range. Each subsequent interface is assigned a VLAN ID, which is the specified *vlan-id* plus the subinterface number minus the first subinterface number (VLAN ID + subinterface number – first subinterface number).
Step 5	**no shutdown** **Example:** `Router(config-if)# no shutdown`	Activates the interface. • This command is required only if you shut down the interface.
Step 6	**exit** **Example:** `Router(config-if)# exit`	Returns to privileged EXEC mode.

	Command	Purpose
Step 7	**show running-config** **Example:** `Router# show running-config`	Verifies subinterface configuration.
Step 8	**show interfaces** **Example:** `Router# show interfaces`	Verifies that subinterfaces have been created.

Configuring Routing Between VLANs with Inter-Switch Link Encapsulation

This section describes the Inter-Switch Link (ISL) protocol and provides guidelines for configuring ISL and Token Ring ISL (TRISL) features. This section contains the following:

- Frame Tagging in ISL, page 15
- Configuring AppleTalk Routing over ISL, page 16
- Configuring Banyan VINES Routing over ISL, page 18
- Configuring DECnet Routing over ISL, page 19
- Configuring the Hot Standby Router Protocol over ISL, page 20
- Configuring IP Routing over TRISL, page 22
- Configuring IPX Routing on 802.10 VLANs over ISL, page 23
- Configuring IPX Routing over TRISL, page 25
- Configuring VIP Distributed Switching over ISL, page 26
- Configuring XNS Routing over ISL, page 28
- Configuring CLNS Routing over ISL, page 29
- Configuring IS-IS Routing over ISL, page 30

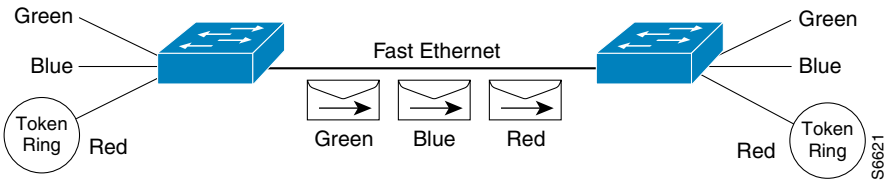
Frame Tagging in ISL

ISL is a Cisco protocol for interconnecting multiple switches and maintaining VLAN information as traffic goes between switches. ISL provides VLAN capabilities while maintaining full wire speed performance on Fast Ethernet links in full- or half-duplex mode. ISL operates in a point-to-point environment and will support up to 1000 VLANs. You can define virtually as many logical networks as are necessary for your environment.

With ISL, an Ethernet frame is encapsulated with a header that transports VLAN IDs between switches and routers. A 26-byte header that contains a 10-bit VLAN ID is propounded to the Ethernet frame.

A VLAN ID is added to the frame only when the frame is prepended for a nonlocal network. Figure 78 shows VLAN packets traversing the shared backbone. Each VLAN packet carries the VLAN ID within the packet header.

Figure 78 VLAN Packets Traversing the Shared Backbone



You can configure routing between any number of VLANs in your network. This section documents the configuration tasks for each protocol supported with ISL encapsulation. The basic process is the same, regardless of the protocol being routed. It involves the following tasks:

- Enabling the protocol on the router
- Enabling the protocol on the interface
- Defining the encapsulation format as ISL or TRISL
- Customizing the protocol according to the requirements for your environment

Configuring AppleTalk Routing over ISL

AppleTalk can be routed over VLAN subinterfaces using the ISL and IEEE 802.10 VLAN encapsulation protocols. The AppleTalk Routing over ISL and IEEE 802.10 Virtual LANs feature provides full-feature Cisco IOS software AppleTalk support on a per-VLAN basis, allowing standard AppleTalk capabilities to be configured on VLANs.

To route AppleTalk over ISL or IEEE 802.10 between VLANs, you need to customize the subinterface to create the environment in which it will be used. Perform the steps in the order in which they appear.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **appletalk routing** [**eigrp** *router-number*]
4. **interface** *type slot/port.subinterface-number*
5. **encapsulation isl** *vlan-identifier*

   or

   encapsulation sde *said*
6. **appletalk cable-range** *cable-range* [*network.node*]
7. **appletalk zone** *zone-name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**appletalk routing** [**eigrp** *router-number*] **Example:** `Router(config)# appletalk routing`	Enables AppleTalk routing globally on either ISL or 802.10 interfaces.
Step 4	**interface** *type slot*/*port*.*subinterface-number* **Example:** `Router(config)# interface Fddi 1/0.100`	Specifies the subinterface the VLAN will use.
Step 5	**encapsulation isl** *vlan-identifier* or **encapsulation sde** *said* **Example:** `Router(config-if)#  encapsulation sde 100`	Defines the encapsulation format as either ISL (**isl**) or IEEE 802.10 (**sde**), and specifies the VLAN identifier or security association identifier, respectively.
Step 6	**appletalk cable-range** *cable-range* [*network*.*node*] **Example:** `Router(config-if)#  appletalk cable-range 100-100 100.2`	`Assigns the AppleTalk cable range and zone for the subinterface.`
Step 7	**appletalk zone** *zone-name* **Example:** `Router(config-if)# appletalk zone 100`	Assigns the AppleTalk zone for the subinterface.

Configuring Banyan VINES Routing over ISL

Banyan VINES can be routed over VLAN subinterfaces using the ISL encapsulation protocol. The Banyan VINES Routing over ISL Virtual LANs feature provides full-feature Cisco IOS software Banyan VINES support on a per-VLAN basis, allowing standard Banyan VINES capabilities to be configured on VLANs.

To route Banyan VINES over ISL between VLANs, you need to configure ISL encapsulation on the subinterface. Perform the steps in the following task in the order in which they appear:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vines routing** [*address*]
4. **interface** *type slot*/*port*.*subinterface-number*
5. *encapsulation isl vlan-identifier*
6. **vines metric** [*whole* [*fraction*]]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**vines routing** [*address*] **Example:** `Router(config)# vines routing`	Enables Banyan VINES routing globally.
Step 4	**interface** *type slot*/*port*.*subinterface-number* **Example:** `Router(config)# interface fastethernet 1/0.1`	Specifies the subinterface on which ISL will be used.
Step 5	**encapsulation isl** *vlan-identifier* **Example:** `Router(config-if)# encapsulation isl 200`	Defines the encapsulation format as ISL (**isl**), and specifies the VLAN identifier.
Step 6	**vines metric** [*whole* [*fraction*]] **Example:** `Router(config-if)#vines metric 2`	Enables VINES routing metric on an interface.

Configuring DECnet Routing over ISL

DECnet can be routed over VLAN subinterfaces using the ISL VLAN encapsulation protocols. The DECnet Routing over ISL Virtual LANs feature provides full-feature Cisco IOS software DECnet support on a per-VLAN basis, allowing standard DECnet capabilities to be configured on VLANs.

To route DECnet over ISL VLANs, you need to configure ISL encapsulation on the subinterface. Perform the steps described in the following task in the order in which they appear.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **decnet** [*network-number*] **routing** [*decnet-address*]
4. **interface** *type slot*/*port*.*subinterface-number*
5. **encapsulation isl** *vlan-identifier*
6. **decnet cost** [*cost-value*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

Step 3	`Router(config)# decnet [network-number] routing [decnet-address]`
	
	Example:
	`Router(config)# decnet routing 2.1`
		Enables DECnet on the router.

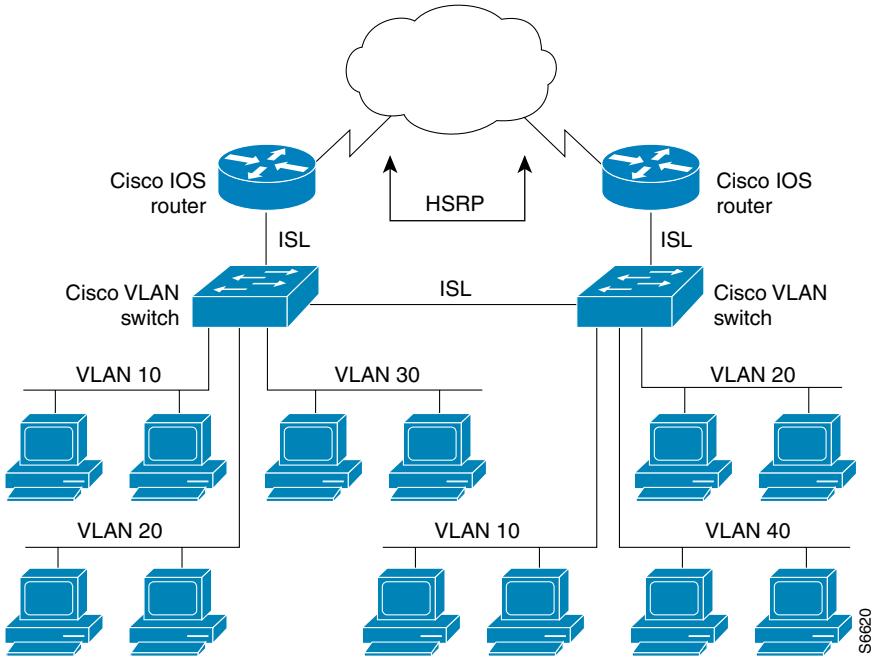
Step 4	**interface** *type slot*/*port*.*subinterface-number* **Example:** `Router(config)# interface fastethernet 1/0.1`	Specifies the subinterface on which ISL will be used.
Step 5	**encapsulation isl** *vlan-identifier* **Example:** `Router(config-if)# encapsulation isl 200`	Defines the encapsulation format as ISL (**isl**), and specifies the VLAN identifier.
Step 6	**decnet cost** [*cost-value*] **Example:** `Router(config-if)# decnet cost 4`	Enables DECnet cost metric on an interface.

Configuring the Hot Standby Router Protocol over ISL

The Hot Standby Router Protocol (HSRP) provides fault tolerance and enhanced routing performance for IP networks. HSRP allows Cisco IOS routers to monitor each other's operational status and very quickly assume packet forwarding responsibility in the event the current forwarding device in the HSRP group fails or is taken down for maintenance. The standby mechanism remains transparent to the attached hosts and can be deployed on any LAN type. With multiple Hot Standby groups, routers can simultaneously provide redundant backup and perform loadsharing across different IP subnets.

Figure 79 illustrates HSRP in use with ISL providing routing between several VLANs.

Figure 79 Hot Standby Router Protocol in VLAN Configurations



A separate HSRP group is configured for each VLAN subnet so that Cisco IOS router A can be the primary and forwarding router for VLANs 10 and 20. At the same time, it acts as backup for VLANs 30 and 40. Conversely, Router B acts as the primary and forwarding router for ISL VLANs 30 and 40, as well as the secondary and backup router for distributed VLAN subnets 10 and 20.

Running HSRP over ISL allows users to configure redundancy between multiple routers that are configured as front ends for VLAN IP subnets. By configuring HSRP over ISLs, users can eliminate situations in which a single point of failure causes traffic interruptions. This feature inherently provides some improvement in overall networking resilience by providing load balancing and redundancy capabilities between subnets and VLANs.

To configure HSRP over ISLs between VLANs, you need to create the environment in which it will be used. Perform the tasks described in the following sections in the order in which they appear.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type slot*/*port*.*subinterface-number*

4. **encapsulation isl** *vlan-identifier*
5. **ip address** *ip-address mask* [**secondary**]
6. **standby** [*group-number*] **ip** [*ip-address* [**secondary**]]
7. **standby** [*group-number*] **timers** *hellotime holdtime*
8. **standby** [*group-number*] **priority** *priority*
9. **standby** [*group-number*] **preempt**
10. **standby** [*group-number*] **track** *type-number* [*interface-priority*]
11. **standby** [*group-number*] **authentication** *string*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	`Router(config)# interface` *type slot/port.subinterface-number* **Example:** `Router(config)# interface FastEthernet 1/1.110`	Specifies the subinterface on which ISL will be used.
Step 4	**encapsulation isl** *vlan-identifier* **Example:** `Router(config-if)#  encapsulation isl 110`	Defines the encapsulation format, and specifies the VLAN identifier.
Step 5	**ip address** *ip-address mask* [**secondary**] **Example:** `Router(config-if)# ip address 10.1.1.2 255.255.255.0`	Specifies the IP address for the subnet on which ISL will be used.
Step 6	`Router(config-if)# standby` [*group-number*] **ip** [*ip-address* [**secondary**]] **Example:** `Router(config-if)# standby 1 ip 10.1.1.101`	Enables HSRP.
Step 7	`Router(config-if)# standby` [*group-number*] **timers** *hellotime holdtime* **Example:** `Router(config-if)# standby 1 timers 10 10`	Configures the time between hello packets and the hold time before other routers declare the active router to be down.

	Command or Action	Purpose

Step 8	`Router(config-if)# standby [group-number] priority priority`
	
	Example:
	`Router(config-if)# standby 1 priority 105`
		Sets the Hot Standby priority used to choose the active router.

Step 9	`Router(config-if)# standby [group-number] preempt`
	
	Example:
	`Router(config-if)# standby 1 priority 105`
		Specifies that if the local router has priority over the current active router, the local router should attempt to take its place as the active router.

Step 10	`Router(config-if)# standby [group-number] track type-number [interface-priority]`
	
	Example:
	`Router(config-if)# standby 1 track 4 5`
		Configures the interface to track other interfaces, so that if one of the other interfaces goes down, the Hot Standby priority for the device is lowered.

Step 11	`Router(config-if)# standby [group-number] authentication string`
	
	Example:
	`Router(config-if)# standby 1 authentication hsrpword7`
		Selects an authentication string to be carried in all HSRP messages.

Note For more information on HSRP, see the "Configuring IP Services" chapter in the *Cisco IOS IP Configuration Guide*.

Configuring IP Routing over TRISL

The IP routing over TRISL VLANs feature extends IP routing capabilities to include support for routing IP frame types in VLAN configurations.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip routing**
4. **interface** *type slot/port.subinterface-number*
5. **encapsulation tr-isl trbrf-vlan** *vlanid* **bridge-num** *bridge-number*
6. **ip address** *ip-address mask*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip routing** **Example:** `Router(config)# ip routing`	Enables IP routing on the router.
Step 4	**interface** *type slot/port.subinterface-number* **Example:** `Router(config# interface FastEthernet4/0.1`	Specifies the subinterface on which TRISL will be used.
Step 5	**encapsulation tr-isl trbrf-vlan** *vlanid* **bridge-num** *bridge-number* **Example:** `Router(config-if# encapsulation tr-isl trbrf-vlan 999 bridge-num 14`	Defines the encapsulation for TRISL. • The DRiP database is automatically enabled when TRISL encapsulation is configured, and at least one TrBRF is defined, and the interface is configured for SRB or for routing with RIF
Step 6	**ip address** *ip-address mask* **Example:** `Router(config-if# ip address 10.5.5.1 255.255.255.0`	Sets a primary IP address for an interface. • A mask identifies the bits that denote the network number in an IP address. When you use the mask to subnet a network, the mask is then referred to as a *subnet mask*. **Note** TRISL encapsulation must be specified for a subinterface before an IP address can be assigned to that subinterface.

Configuring IPX Routing on 802.10 VLANs over ISL

The IPX Encapsulation for 802.10 VLAN feature provides configurable IPX (Novell-FDDI, SAP, SNAP) encapsulation over 802.10 VLAN on router FDDI interfaces to connect the Catalyst 5000 VLAN switch. This feature extends Novell NetWare routing capabilities to include support for routing all standard IPX encapsulations for Ethernet frame types in VLAN configurations. Users with Novell NetWare environments can now configure any one of the three IPX Ethernet encapsulations to be routed using Secure Data Exchange (SDE) encapsulation across VLAN boundaries. IPX encapsulation options now supported for VLAN traffic include the following:

- Novell-FDDI (IPX FDDI RAW to 802.10 on FDDI)
- SAP (IEEE 802.2 SAP to 802.10 on FDDI)

- SNAP (IEEE 802.2 SNAP to 802.10 on FDDI)

NetWare users can now configure consolidated VLAN routing over a single VLAN trunking FDDI interface. Not all IPX encapsulations are currently supported for SDE VLAN. The IPX interior encapsulation support can be achieved by messaging the IPX header before encapsulating in the SDE format. Fast switching will also support all IPX interior encapsulations on non-MCI platforms (for example non-AGS+ and non-7000). With configurable Ethernet encapsulation protocols, users have the flexibility of using VLANs regardless of their NetWare Ethernet encapsulation. Configuring Novell IPX encapsulations on a per-VLAN basis facilitates migration between versions of Netware. NetWare traffic can now be routed across VLAN boundaries with standard encapsulation options (*arpa*, *sap*, and *snap*) previously unavailable. Encapsulation types and corresponding framing types are described in the "Configuring Novell IPX" chapter of the *Cisco IOS AppleTalk and Novell IPX Configuration Guide*.

Note Only one type of IPX encapsulation can be configured per VLAN (subinterface). The IPX encapsulation used must be the same within any particular subnet; a single encapsulation must be used by all NetWare systems that belong to the same VLAN.

To configure Cisco IOS software on a router with connected VLANs to exchange different IPX framing protocols, perform the steps described in the following task in the order in which they are appear.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipx routing** [*node*]
4. **interface** *fddi slot/port.subinterface-number*
5. **encapsulation sde** *vlan-identifier*
6. **ipx network** *network* **encapsulation** *encapsulation-type*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ipx routing** [*node*] **Example:** `Router(config)# ipx routing`	Enables IPX routing globally.

	Command or Action	Purpose
Step 4	**interface** *fddi slot/port.subinterface-number* **Example:** `Router(config)# interface 2/0.1`	Specifies the subinterface on which SDE will be used.
Step 5	**encapsulation sde** *vlan-identifier* **Example:** `Router(config-if)# encapsulation isl 20`	Defines the encapsulation format and specifies the VLAN identifier.
Step 6	**ipx network** *network* **encapsulation** *encapsulation-type* ***Example:*** `Router(config-if)# ipx network 20 encapsulation sap`	Specifies the IPX encapsulation among Novell-FDDI, SAP, or SNAP.

Configuring IPX Routing over TRISL

The IPX Routing over ISL VLANs feature extends Novell NetWare routing capabilities to include support for routing all standard IPX encapsulations for Ethernet frame types in VLAN configurations. Users with Novell NetWare environments can configure either SAP or SNAP encapsulations to be routed using the TRISL encapsulation across VLAN boundaries. The SAP (Novell Ethernet_802.2) IPX encapsulation is supported for VLAN traffic.

NetWare users can now configure consolidated VLAN routing over a single VLAN trunking interface. With configurable Ethernet encapsulation protocols, users have the flexibility of using VLANs regardless of their NetWare Ethernet encapsulation. Configuring Novell IPX encapsulations on a per-VLAN basis facilitates migration between versions of Netware. NetWare traffic can now be routed across VLAN boundaries with standard encapsulation options (*sap* and *snap*) previously unavailable. Encapsulation types and corresponding framing types are described in the "Configuring Novell IPX" chapter of the *Cisco IOS AppleTalk and Novell IPX Configuration Guide*.

Note Only one type of IPX encapsulation can be configured per VLAN (subinterface). The IPX encapsulation used must be the same within any particular subnet: A single encapsulation must be used by all NetWare systems that belong to the same LANs.

To configure Cisco IOS software to exchange different IPX framing protocols on a router with connected VLANs, perform the steps in the following task in the order in which they are appear.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipx routing** [*node*]
4. **interface** *type slot/port.subinterface-number*
5. **encapsulation tr-isl trbrf-vlan** *trbrf-vlan* **bridge-num** *bridge-num*
6. **ipx network** *network* **encapsulation** *encapsulation-type*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ipx routing** [*node*] **Example:** `Router(config)# source-bridge ring-group 100`	Enables IPX routing globally.
Step 4	**interface** *type slot/port.subinterface-number* **Example:** `Router(config-if)# interface TokenRing 3/1`	Specifies the subinterface on which TRISL will be used.
Step 5	**encapsulation tr-isl trbrf-vlan** *trbrf-vlan* **bridge-num** *bridge-num* **Example:** `Router(config-if)#encapsulation tr-isl trbrf-vlan 999 bridge-num 14`	Defines the encapsulation for TRISL.
Step 6	**ipx network** *network* **encapsulation** *encapsulation-type* **Example:** `Router(config-if)# ipx network 100 encapsulation sap`	Specifies the IPX encapsulation on the subinterface by specifying the NetWare network number (if necessary) and the encapsulation type.

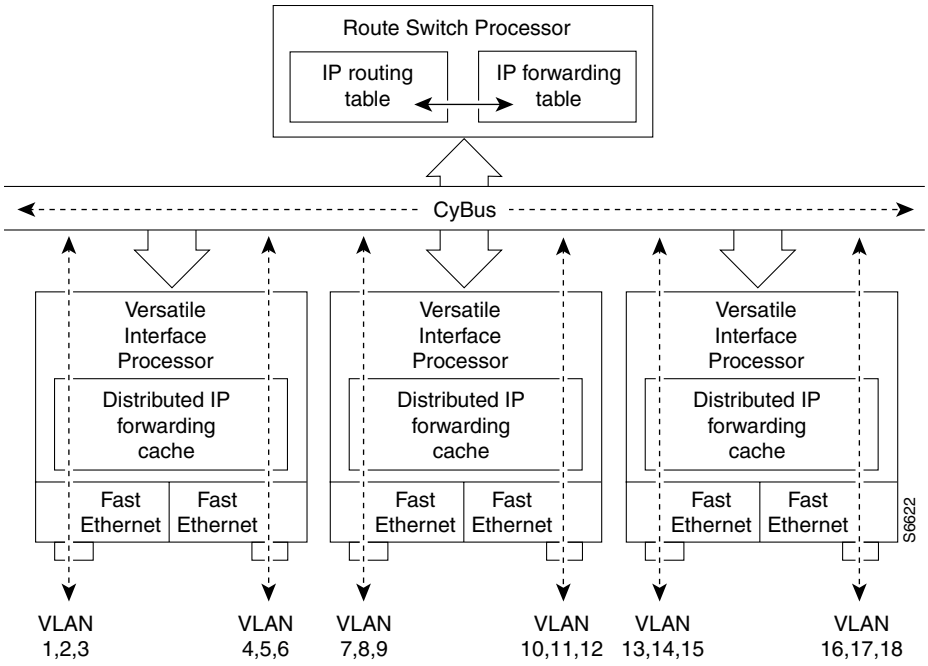
Note The default IPX encapsulation format for Cisco IOS routers is “novell-ether” (Novell Ethernet_802.3). If you are running Novell Netware 3.12 or 4.0, the new Novell default encapsulation format is Novell Ethernet_802.2 and you should configure the Cisco router with the IPX encapsulation format “sap.”

Configuring VIP Distributed Switching over ISL

With the introduction of the VIP distributed ISL feature, ISL encapsulated IP packets can be switched on Versatile Interface Processor (VIP) controllers installed on Cisco 7500 series routers.

The second generation VIP2 provides distributed switching of IP encapsulated in ISL in VLAN configurations. Where an aggregation route performs inter-VLAN routing for multiple VLANs, traffic can be switched autonomously on-card or between cards rather than through the central Route Switch Processor (RSP). Figure 80 shows the VIP distributed architecture of the Cisco 7500 series router.

Figure 80 Cisco 7500 Distributed Architecture



This distributed architecture allows incremental capacity increases by installation of additional VIP cards. Using VIP cards for switching the majority of IP VLAN traffic in multiprotocol environments substantially increases routing performance for the other protocols because the RSP offloads IP and can then be dedicated to switching the non-IP protocols.

VIP distributed switching offloads switching of ISL VLAN IP traffic to the VIP card, removing involvement from the main CPU. Offloading ISL traffic to the VIP card substantially improves networking performance. Because you can install multiple VIP cards in a router, VLAN routing capacity is increased linearly according to the number of VIP cards installed in the router.

To configure distributed switching on the VIP, you must first configure the router for IP routing. Perform the tasks described in the following task in the order in which they appear.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip routing**
4. **interface** *type slot*/*port-adapter*/*port*
5. **ip route-cache distributed**
6. **encapsulation isl** *vlan-identifier*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip routing** **Example:** `Router(config)# ip routing`	Enables IP routing on the router. • Refer to the IP configuration chapters in the *Cisco IOS IP Routing Configuration Guide* for guidelines on configuring IP.
Step 4	**interface** *type slot/port-adapter/port* **Example:** `Router(config)# interface FastEthernet1/0/0`	Specifies the interface and interface configuration mode.
Step 5	**ip route-cache distributed** **Example:** `Router(config-if)# ip route-cache distributed`	Enables VIP distributed switching of IP packets on the interface.
Step 6	**encapsulation isl** *vlan-identifier* **Example:** `Router(config-if)# encapsulation isl 1`	Defines the encapsulation format as ISL, and specifies the VLAN identifier.

Configuring XNS Routing over ISL

XNS can be routed over VLAN subinterfaces using the ISL VLAN encapsulation protocol. The XNS Routing over ISL Virtual LANs feature provides full-feature Cisco IOS software XNS support on a per-VLAN basis, allowing standard XNS capabilities to be configured on VLANs.

To route XNS over ISL VLANs, you need to configure ISL encapsulation on the subinterface. Perform the steps described in the following task in the order in which they appear.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **xns routing** [*address*]
4. **interface** *type slot*/*port*.*subinterface-number*
5. **encapsulation isl** *vlan-identifier*
6. **xns network** [*number*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**xns routing** [*address*] **Example:** `Router(config)# xns routing 0123.4567.adcb`	Enables XNS routing globally.
Step 4	**interface** *type slot/port.subinterface-number* **Example:** `Router(config)# interface fastethernet 1/0.1`	Specifies the subinterface on which ISL will be used.
Step 5	**encapsulation isl** *vlan-identifier* **Example:** `Router(config-if)# encapsulation isl 100`	Defines the encapsulation format as ISL (**isl**), and specifies the VLAN identifier.
Step 6	**xns network** [*number*] **Example:** `Router(config-if)# xns network 20`	Enables XNS routing on the subinterface.

Configuring CLNS Routing over ISL

CLNS can be routed over VLAN subinterfaces using the ISL VLAN encapsulation protocol. The CLNS Routing over ISL Virtual LANs feature provides full-feature Cisco IOS software CLNS support on a per-VLAN basis, allowing standard CLNS capabilities to be configured on VLANs.

To route CLNS over ISL VLANs, you need to configure ISL encapsulation on the subinterface. Perform the steps described in the following task in the order in which they appear.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **clns routing**
4. **interface** *type slot/port.subinterface-number*
5. **encapsulation isl** *vlan-identifier*
6. **clns enable**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**clns routing** **Example:** `Router(config)# clns routing`	Enables CLNS routing globally.
Step 4	**interface** *type slot/port.subinterface-number* **Example:** `Router(config-if)# interface fastethernet 1/0.1`	Specifies the subinterface on which ISL will be used.
Step 5	**encapsulation isl** *vlan-identifier* **Example:** `Router(config-if)# encapsulation isl 100`	Defines the encapsulation format as ISL (**isl**), and specifies the VLAN identifier.
Step 6	**clns enable** **Example:** `Router(config-if)# clns enable`	Enables CLNS routing on the subinterface.

Configuring IS-IS Routing over ISL

IS-IS routing can be enabled over VLAN subinterfaces using the ISL VLAN encapsulation protocol. The IS-IS Routing over ISL Virtual LANs feature provides full-feature Cisco IOS software IS-IS support on a per-VLAN basis, allowing standard IS-IS capabilities to be configured on VLANs.

To enable IS-IS over ISL VLANs, you need to configure ISL encapsulation on the subinterface. Perform the steps described in the following task in the order in which they appear.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router isis** [*tag*]
4. **net** *network-entity-title*
5. **interface** *type slot/port.subinterface-number*
6. **encapsulation isl** *vlan-identifier*
7. **clns router isis network** [*tag*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**router isis** [*tag*] **Example:** `Router(config)# isis routing test-proc2`	Enables IS-IS routing, and enters router configuration mode.
Step 4	**net** *network-entity-title* **Example:** `Router(config)# net 49.0001.0002.aaaa.aaaa.aaaa.00`	Configures the NET for the routing process.
Step 5	**interface** *type slot*/*port*.*subinterface-number* **Example:** `Router(config-if)# interface fastethernet 2.`	Specifies the subinterface on which ISL will be used.
Step 6	**encapsulation isl** *vlan-identifier* **Example:** `Router(config-if)# encapsulation isl 101`	Defines the encapsulation format as ISL (**isl**), and specifies the VLAN identifier.
Step 7	**clns router isis network** [*tag*] **Example:** `Router(config-if)# clns router is-is network test-proc2`	Specifies the interfaces that should be actively routing IS-IS.

Configuring Routing Between VLANs with IEEE 802.10 Encapsulation

This section describes the required and optional tasks for configuring routing between VLANs with IEEE 802.10 encapsulation.

HDLC serial links can be used as VLAN trunks in IEEE 802.10 VLANs to extend a virtual topology beyond a LAN backbone.

AppleTalk can be routed over VLAN subinterfaces using the ISL or IEEE 802.10 VLANs feature that provides full-feature Cisco IOS software AppleTalk support on a per-VLAN basis, allowing standard AppleTalk capabilities to be configured on VLANs.

AppleTalk users can now configure consolidated VLAN routing over a single VLAN trunking interface. Prior to introduction of this feature, AppleTalk could be routed only on the main interface on a LAN port. If AppleTalk routing was disabled on the main interface or if the main interface was shut down, the

entire physical interface would stop routing any AppleTalk packets. With this feature enabled, AppleTalk routing on subinterfaces will be unaffected by changes in the main interface with the main interface in the "no-shut" state.

To route AppleTalk over IEEE 802.10 between VLANs, create the environment in which it will be used by customizing the subinterface and perform the tasks described in the following steps in the order in which they appear.

SUMMARY STEPS

1. enable
2. configure terminal
3. appletalk routing [**eigrp** *router-number*]
4. **interface fastethernet** *slot/port.subinterface-number*
5. **appletalk cable-range** *cable-range* [*network.node*]
6. **appletalk zone** *zone-name*
7. **encapsulation sde** *said*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**appletalk routing** [**eigrp** *router-number*] **Example:** `Router(config)# appletalk routing`	Enables AppleTalk routing globally.
Step 4	**interface fastethernet** *slot/port.subinterface-number* **Example:** `Router(config)# interface fastethernet 4/1.00`	Specifies the subinterface the VLAN will use.
Step 5	**appletalk cable-range** *cable-range* [*network.node*] **Example:** `Router(config-if)# appletalk 100-100 100.1`	Assigns the AppleTalk cable range and zone for the subinterface.

	Command or Action	Purpose
Step 6	**appletalk zone** *zone-name* **Example:** `Router(config-if)# appletalk zone eng`	Assigns the AppleTalk zone for the subinterface.
Step 7	**encapsulation sde** *said* **Example:** `Router(config-if)# encapsulation sde 100`	Defines the encapsulation format as IEEE 802.10 (sde) and specifies the VLAN identifier or security association identifier, respectively.

Note For more information on configuring AppleTalk, see the "Configuring AppleTalk" chapter in the *Cisco IOS AppleTalk and Novell IPX Configuration Guide*.

Configuring Routing Between VLANs with IEEE 802.1Q Encapsulation

This section describes the required and optional tasks for configuring routing between VLANs with IEEE 802.1Q encapsulation. The IEEE 802.1Q protocol is used to interconnect multiple switches and routers, and for defining VLAN topologies.

Prerequisites

Configuring routing between VLANs with IEEE 802.1Q encapsulation assumes the presence of a single spanning tree and of an explicit tagging scheme with one-level tagging.

You can configure routing between any number of VLANs in your network.

Restrictions

The IEEE 802.1Q standard is extremely restrictive to untagged frames. The standard provides only a per-port VLANs solution for untagged frames. For example, assigning untagged frames to VLANs takes into consideration only the port from which they have been received. Each port has a parameter called a *permanent virtual identification* (Native VLAN) that specifies the VLAN assigned to receive untagged frames.

The main characteristics of the IEEE 802.1Q are that it assigns frames to VLANs by filtering and that the standard assumes the presence of a single spanning tree and of an explicit tagging scheme with one-level tagging.

This section contains the configuration tasks for each protocol supported with IEEE 802.1Q encapsulation. The basic process is the same, regardless of the protocol being routed. It involves the following tasks:

- Enabling the protocol on the router
- Enabling the protocol on the interface
- Defining the encapsulation format as IEEE 802.1Q
- Customizing the protocol according to the requirements for your environment

To configure IEEE 802.1Q on your network, perform the following tasks. One of the following tasks is required depending on the protocol being used.

- Configuring AppleTalk Routing over IEEE 802.1Q (required)
- Configuring IP Routing over IEEE 802.1Q (required)
- Configuring IPX Routing over IEEE 802.1Q (required)

The following tasks are optional. Perform the following tasks to connect a network of hosts over a simple bridging-access device to a remote access concentrator bridge between IEEE 802.1Q VLANs. The following sections contain configuration tasks for the Integrated Routing and Bridging, Transparent Bridging, and PVST+ Between VLANs with IEEE 802.1Q Encapsulation:

- Configuring a VLAN for a Bridge Group with Default VLAN1 (optional)
- Configuring a VLAN for a Bridge Group as a Native VLAN (optional)

Configuring AppleTalk Routing over IEEE 802.1Q

AppleTalk can be routed over virtual LAN (VLAN) subinterfaces using the IEEE 802.1Q VLAN encapsulation protocol. AppleTalk Routing provides full-feature Cisco IOS software AppleTalk support on a per-VLAN basis, allowing standard AppleTalk capabilities to be configured on VLANs.

To route AppleTalk over IEEE 802.1Q between VLANs, you need to customize the subinterface to create the environment in which it will be used. Perform the steps in the order in which they appear.

Use the following task to enable AppleTalk routing on IEEE 802.1Q interfaces.

SUMMARY STEPS

1. enable
2. configure terminal
3. appletalk routing [**eigrp** *router-number*]
4. **interface fastethernet** *slot/port.subinterface-number*
5. **encapsulation dot1q** *vlan-identifier*
6. **appletalk cable-range** *cable-range* [*network.node*]
7. **appletalk zone** *zone-name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**appletalk routing** [**eigrp** *router-number*] **Example:** `Router(config)# appletalk routing`	Enables AppleTalk routing globally.
Step 4	**interface fastethernet** *slot/port.subinterface-number* **Example:** `Router(config)# interface fastethernet 4/1.00`	Specifies the subinterface the VLAN will use.
Step 5	**encapsulation dot1q** *vlan-identifier* **Example:** `Router(config-if)# encapsulation dot1q 100`	Defines the encapsulation format as IEEE 802.1Q (**dot1q**), and specifies the VLAN identifier.

	Command or Action	Purpose
Step 6	**appletalk cable-range** *cable-range* [*network.node*] **Example:** `Router(config-if)# appletalk cable-range 100-100 100.1`	Assigns the AppleTalk cable range and zone for the subinterface.
Step 7	**appletalk zone** *zone-name* **Example:** `Router(config-if)# appletalk zone eng`	Assigns the AppleTalk zone for the subinterface.

Note For more information on configuring AppleTalk, see the "Configuring AppleTalk" chapter in the *Cisco IOS AppleTalk and Novell IPX Configuration Guide*.

Configuring IP Routing over IEEE 802.1Q

IP routing over IEEE 802.1Q extends IP routing capabilities to include support for routing IP frame types in VLAN configurations using the IEEE 802.1Q encapsulation.

To route IP over IEEE 802.1Q between VLANs, you need to customize the subinterface to create the environment in which it will be used. Perform the tasks described in the following sections in the order in which they appear.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip routing**
4. **interface fastethernet** *slot/port.subinterface-number*
5. **encapsulation dotlq** *vlanid*
6. ip address ip-address mask

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose

Step 3	`ip routing`
	
	Example:
	`Router(config)# ip routing`
		Enables IP routing on the router.

Step 4	**interface fastethernet** *slot/port.subinterface-number* **Example:** `Router(config)# interface fastethernet 4/1.101`	Specifies the subinterface on which IEEE 802.1Q will be used.
Step 5	**encapsulation dot1q** *vlanid* **Example:** `Router(config-if)# encapsulation dot1q 101`	Defines the encapsulation format at IEEE.802.1Q (dot1q) and specifies the VLAN identifier.
Step 6	**ip address** *ip-address mask* **Example:** `Router(config-if)# ip addr 10.0.0.11 255.0.0.0`	Sets a primary IP address and mask for the interface.

Once you have IP routing enabled on the router, you can customize the characteristics to suit your environment. If necessary, refer to the IP configuration chapters in the *Cisco IOS IP Routing Configuration Guide* for guidelines on configuring IP.

Configuring IPX Routing over IEEE 802.1Q

IPX routing over IEEE 802.1Q VLANs extends Novell NetWare routing capabilities to include support for routing Novell Ethernet_802.3 encapsulation frame types in VLAN configurations. Users with Novell NetWare environments can configure Novell Ethernet_802.3 encapsulation frames to be routed using IEEE 802.1Q encapsulation across VLAN boundaries.

To configure Cisco IOS software on a router with connected VLANs to exchange IPX Novell Ethernet_802.3 encapsulated frames, perform the steps described in the following task in the order in which they appear.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipx routing [*node*]**
4. **interface fastethernet** *slot/port.subinterface-number*
5. **encapsulation dotlq** *vlanid*
6. ipx network network

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ipx routing** [*node*] **Example:** `Router(config)# ipx routing`	Enables IPX routing globally.
Step 4	**interface fastethernet** *slot*/*port*.*subinterface-number* **Example:** `Router(config)# interface fastethernet 4/1.102`	Specifies the subinterface on which IEEE 802.1Q will be used.
Step 5	**encapsulation dot1q** *vlanid* **Example:** `Router(config-if)# encapsulation dot1q 102`	Defines the encapsulation format at IEEE.802.1Q (**dot1q**) and specifies the VLAN identifier.
Step 6	**ipx network** *network* **Example:** `Router(config-if)# ipx network 100`	Specifies the IPX network number.

Configuring a VLAN for a Bridge Group with Default VLAN1

Use the following task to configure a VLAN associated with a bridge group with a default native VLAN.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface fastethernet** *slot*/*port*.*subinterface-number*
4. **encapsulation dotlq** *vlanid*
5. bridge-group bridge-group

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface fastethernet** *slot/port.subinterface-number* **Example:** `Router(config)# interface fastethernet 4/1.100`	Selects a particular interface to configure.
Step 4	**encapsulation dot1q** *vlanid* **Example:** `Router(config-subif)# encapsulation dot1q 1`	Defines the encapsulation format at IEEE.802.1Q (dot1q) and specifies the VLAN identifier. • The specified VLAN is by default the native VLAN. **Note** If there is no explicitly defined native VLAN, the default VLAN1 becomes the native VLAN.
Step 5	**bridge-group** *bridge-group* **Example:** `Router(config-subif)# bridge-group 1`	Assigns the bridge group to the interface.

Configuring a VLAN for a Bridge Group as a Native VLAN

Use the following task to configure a VLAN associated to a bridge group as a native VLAN.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface fastethernet** *slot/port*
4. **encapsulation dotlq** *vlanid native*
5. bridge-group bridge-group

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface fastethernet** *slot/port.subinterface-number* **Example:** `Router(config)# interface fastethernet 4/1.100`	Selects a particular interface to configure.
Step 4	**encapsulation dot1q** *vlanid* **native** **Example:** `Router(config-subif)# encapsulation dot1q 20 native`	Defines the encapsulation format at IEEE.802.1Q (**dot1q**) and specifies the VLAN identifier. VLAN 20 is specified as the native VLAN. **Note** If there is no explicitly defined native VLAN, the default VLAN1 becomes the native VLAN.
Step 5	**bridge-group** *bridge-group* **Example:** `Router(config-subif)# bridge-group 1`	Assigns the bridge group to the interface.

Note If there is an explicitly defined native VLAN, VLAN1 will only be used to process CST.

Configuring IEEE 802.1Q-in-Q VLAN Tag Termination

Encapsulating IEEE 802.1Q VLAN tags within 802.1Q enables service providers to use a single VLAN to support customers who have multiple VLANs. The IEEE 802.1Q-in-Q VLAN Tag Termination feature on the subinterface level preserves VLAN IDs and keeps traffic in different customer VLANs segregated.

Prerequisites

You must have checked Feature Navigator to verify that your Cisco device and software image support this feature.

You must be connected to an Ethernet device that supports double VLAN tag imposition/disposition or switching.

Restrictions

The following restrictions apply to the Cisco 10000 series Internet router:

- Supported on Ethernet, FastEthernet, or Gigabit Ethernet interfaces.
- Supports only Point-to-Point Protocol over Ethernet (PPPoE) packets that are double-tagged for Q-in-Q VLAN tag termination.
- IP and Multiprotocol Label Switching (MPLS) packets are not supported.
- Modular QoS can be applied to unambiguous subinterfaces only.
- Limited ACL support.

IEEE 802.1Q-in-Q VLAN Tag Termination on Subinterfaces

IEEE 802.1Q-in-Q VLAN Tag Termination simply adds another layer of IEEE 802.1Q tag (called "metro tag" or "PE-VLAN") to the 802.1Q tagged packets that enter the network. The purpose is to expand the VLAN space by tagging the tagged packets, thus producing a "double-tagged" frame. The expanded VLAN space allows the service provider to provide certain services, such as Internet access on specific VLANs for specific customers, and yet still allows the service provider to provide other types of services for their other customers on other VLANs.

Generally the service provider's customers require a range of VLANs to handle multiple applications. Service providers can allow their customers to use this feature to safely assign their own VLAN IDs on subinterfaces because these subinterface VLAN IDs are encapsulated within a service-provider designated VLAN ID for that customer. Therefore there is no overlap of VLAN IDs among customers, nor does traffic from different customers become mixed. The double-tagged frame is "terminated" or assigned on a subinterface with an expanded **encapsulation dot1q** command that specifies the two VLAN ID tags (outer VLAN ID and inner VLAN ID) terminated on the subinterface. See Figure 81 on page 42.

IEEE 802.1Q-in-Q VLAN Tag Termination is generally supported on whichever Cisco IOS features or protocols are supported on the subinterface; the exception is that Cisco 10000 series Internet router only supports PPPoE. For example if you can run PPPoE on the subinterface, you can configure a double-tagged frame for PPPoE. The only restriction is whether you assign ambiguous or unambiguous subinterfaces for the inner VLAN ID. See the "Unambiguous and Ambiguous Subinterfaces" section on page 44.

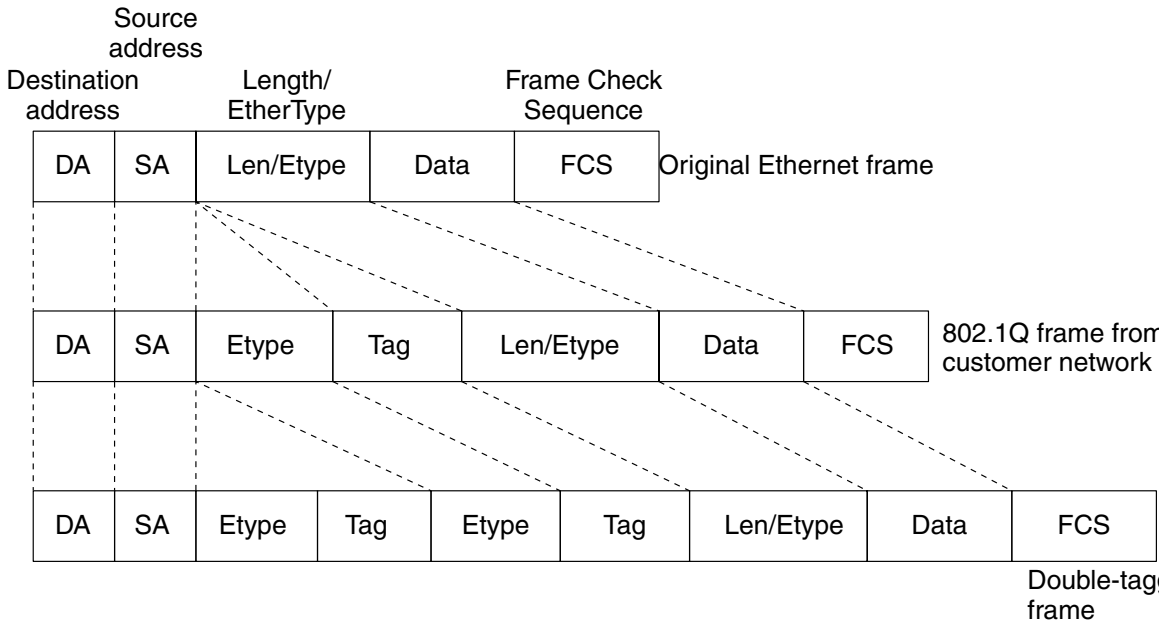
Note The Cisco 10000 series Internet router only supports PPPoE over Q-in-Q (PPPoEQinQ).

The primary benefit for the service provider is reduced number of VLANs supported for the same number of customers. Other benefits of this feature include:

- PPPoE scalability. By expanding the available VLAN space from 4096 to approximately 16.8 million (4096 times 4096), the number of PPPoE sessions that can be terminated on a given interface is multiplied.
- When deploying Gigabyte Ethernet DSL Access Multiplexer (DSLAM) in wholesale model, you can assign the inner VLAN ID to represent the end-customer virtual circuit (VC) and assign the outer VLAN ID to represent the service provider ID.

The Q-in-Q VLAN tag termination feature is simpler than the IEEE 802.1Q tunneling feature deployed for the Catalyst 6500 series switches or the Catalyst 3550 and Catalyst 3750 switches. Whereas switches require IEEE 802.1Q tunnels on interfaces to carry double-tagged traffic, routers need only encapsulate Q-in-Q VLAN tags within another level of 802.1Q tags in order for the packets to arrive at the correct destination as shown in Figure 81.

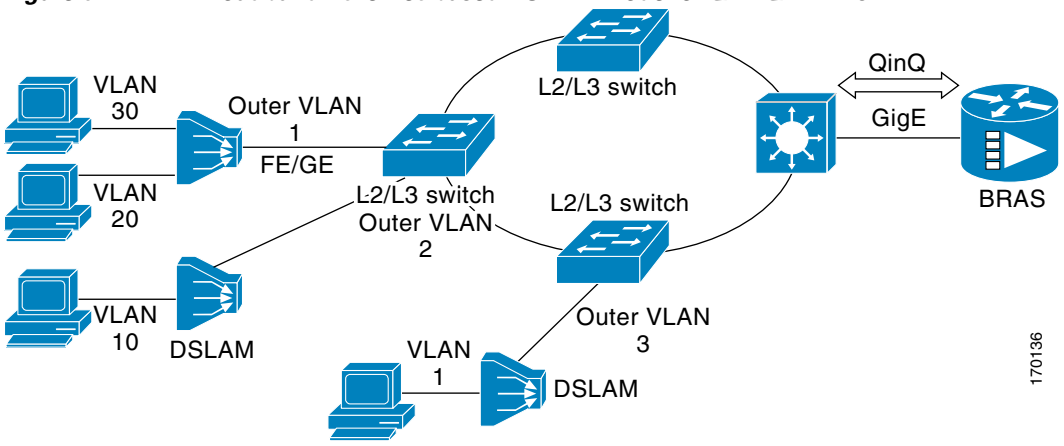
Figure 81 Untagged, 802.1Q-Tagged, and Double-Tagged Ethernet Frames



Cisco 10000 Series Internet Router Application

For the emerging broadband Ethernet-based DSLAM market, the Cisco 10000 series Internet router supports Q-in-Q encapsulation. With the Ethernet-based DSLAM model shown in Figure 82, customers typically get their own VLAN and all these VLANs are aggregated on a DSLAM.

Figure 82 Broadband Ethernet-based DSLAM Model of Q-in-Q VLANs



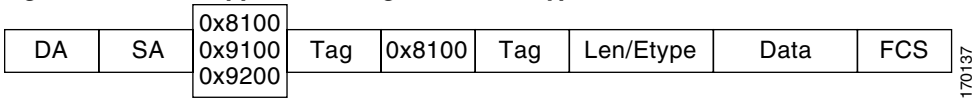
VLAN aggregation on a DSLAM will result in a lot of aggregate VLANs that at some point need to be terminated on the broadband remote access servers (BRAS). Although the model could connect the DSLAMs directly to the BRAS, a more common model uses the existing Ethernet-switched network where each DSLAM VLAN ID is tagged with a second tag (Q-in-Q) as it connects into the Ethernet-switched network.

The only model that is supported is PPPoE over Q-in-Q (PPPoEoQinQ). This can either be a PPP terminated session or as a L2TP LAC session. No IP over Q-in-Q is supported.

The Cisco 10000 series Internet router already supports plain PPPoE and PPP over 802.1Q encapsulation. Supporting PPP over Q-in-Q encapsulation is new. PPP over Q-in-Q encapsulation processing is an extension to 802.1q encapsulation processing. A Q-in-Q frame looks like a VLAN 802.1Q frame, only it has two 802.1Q tags instead of one. See Figure 81.

PPP over Q-in-Q encapsulation supports configurable outer tag Ethertype. The configurable Ethertype field values are 0x8100 (default), 0x9100, and 0x9200. See Figure 83.

Figure 83 Supported Configurable Ethertype Field Values



Security ACL Application on the Cisco 10000 Series Internet Router

The IEEE 802.1Q-in-Q VLAN Tag Termination feature provides limited security access control list (ACL) support for the Cisco 10000 series Internet router.

If you apply an ACL to PPPoE traffic on a Q-in-Q subinterface in a VLAN, apply the ACL directly on the PPPoE session, using virtual access interfaces (VAIs) or RADIUS attribute 11 or 242.

You can apply ACLs to virtual access interfaces by configuring them under virtual template interfaces. You can also configure ACLs by using RADIUS attribute 11 or 242. When you use attribute 242, a maximum of 30,000 sessions can have ACLs.

ACLs that are applied to the VLAN Q-in-Q subinterface have no effect and are silently ignored. In the following example, ACL 1 that is applied to the VLAN Q-in-Q subinterface level will be ignored:

```
Router(config)# interface FastEthernet3/0/0.100
Router(config-subif)# encapsulation dot1q 100 second-dot1q 200
```

```
Router(config-subif)# ip access-group 1
```

Unambiguous and Ambiguous Subinterfaces

The **encapsulation dot1q** command is used to configure Q-in-Q termination on a subinterface. The command accepts an Outer VLAN ID and one or more Inner VLAN IDs. The outer VLAN ID always has a specific value, while inner VLAN ID can either be a specific value or a range of values.

A subinterface that is configured with a single Inner VLAN ID is called an unambiguous Q-in-Q subinterface. In the following example, Q-in-Q traffic with an Outer VLAN ID of 101 and an Inner VLAN ID of 1001 is mapped to the Gigabit Ethernet 1/0.100 subinterface:

```
Router(config)# interface gigabitEehernet1/0.100
Router(config-subif)# encapsulation dot1q 101 second-dot1q 1001
```

A subinterface that is configured with multiple Inner VLAN IDs is called an ambiguous Q-in-Q subinterface. By allowing multiple Inner VLAN IDs to be grouped together, ambiguous Q-in-Q subinterfaces allow for a smaller configuration, improved memory usage and better scalability.

In the following example, Q-in-Q traffic with an Outer VLAN ID of 101 and Inner VLAN IDs anywhere in the 2001-2100 and 3001-3100 range is mapped to the Gigabit Ethernet 1/0.101 subinterface.:

```
Router(config)# interface gigabitethernet1/0.101
Router(config-subif)# encapsulation dot1q 101 second-dot1q 2001-2100,3001-3100
```

Ambiguous subinterfaces can also use the **any** keyword to specify the inner VLAN ID.

See the "Monitoring and Maintaining VLAN Subinterfaces" section on page 50 for an example of how VLAN IDs are assigned to subinterfaces, and for a detailed example of how the **any** keyword is used on ambiguous subinterfaces.

Only PPPoE is supported on ambiguous subinterfaces. Standard IP routing is not supported on ambiguous subinterfaces.

Note On the Cisco 10000 series Internet router, Modular QoS services are only supported on unambiguous subinterfaces.

Perform these tasks to configure the main interface used for the Q-in-Q double tagging and to configure the subinterfaces.

- Configuring EtherType Field for Outer VLAN Tag Termination, page 45 (Optional)
- Configuring the Q-in-Q Subinterface, page 46 (Required)
- Verifying the IEEE 802.1Q-in-Q VLAN Tag Termination, page 47 (Optional)

Prerequisites

For the Cisco 10000 series Internet router:

- PPPoE is already configured.
- Virtual private dial-up network (VPDN) is enabled.

The first task is optional. A step in this task shows you how to configure the EtherType field to be 0x9100 for the outer VLAN tag, if that is required.

After the subinterface is defined, the 802.1Q encapsulation is configured to use the double tagging.

Configuring EtherType Field for Outer VLAN Tag Termination

To configure the EtherType field for Outer VLAN Tag Termination, use the following steps. This task is optional.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **dot1q tunneling ethertype** *ethertype*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Router(config)# interface gigabitethernet 1/0/0`	Configures an interface and enters interface configuration mode.
Step 4	**dot1q tunneling ethertype** *ethertype* **Example:** `Router(config-if)# dot1q tunneling ethertype 0x9100`	(Optional) Defines the Ethertype field type used by peer devices when implementing Q-in-Q VLAN tagging. • Use this command if the Ethertype of peer devices is 0x9100 or 0x9200 (0x9200 is only supported on the Cisco 10000 series Internet router). • Cisco 10000 series Internet router supports both the 0x9100 and 0x9200 Ethertype field types.

Configuring the Q-in-Q Subinterface

Use the following steps to configure Q-in-Q subinterfaces. This task is required.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number.subinterface-number*
4. **encapsulation dot1q** *vlan-id* **second-dot1q** {**any** | *vlan-id* | *vlan-id*-*vlan-id* [,*vlan-id*-*vlan-id*]}
5. pppoe enabled [group *group-name*]
6. **exit**
7. Repeat Step 3 to configure another subinterface.
8. Repeat Step 4 and Step 5 to specify the VLAN tags to be terminated on the subinterface and to enable PPPoE sessions on the subinterface.
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number.subinterface-number* **Example:** `Router(config-if)# interface gigabitethernet 1/0/0.1`	Configures a subinterface and enters subinterface configuration mode.
Step 4	**encapsulation dot1q** *vlan-id* **second-dot1q** {**any** | *vlan-id* | *vlan-id*-*vlan-id*[,*vlan-id*-*vlan-id*]} **Example:** `Router(config-subif)# encapsulation dot1q 100 second-dot1q 200`	(Required) Enables the 802.1Q encapsulation of traffic on a specified subinterface in a VLAN. • Use the **second-dot1q** keyword and the *vlan-id* argument to specify the VLAN tags to be terminated on the subinterface. • In this example, an unambiguous Q-in-Q subinterface is configured because only one inner VLAN ID is specified. • Q-in-Q frames with an outer VLAN ID of 100 and an inner VLAN ID of 200 will be terminated.

	Command or Action	Purpose
Step 5	**pppoe enable** [**group** *group-name*] **Example:** `Router(config-subif)# pppoe enable group vpn1`	Enables PPPoE sessions on a subinterface. • The example specifies that the PPPoE profile, vpn1, will be used by PPPoE sessions on the subinterface.
Step 6	**exit** **Example:** `Router(config-subif)# exit`	Exits subinterface configuration mode and returns to interface configuration mode. • Repeat this step one more time to exit interface configuration mode.
Step 7	Repeat Step3 to configure another subinterface. **Example:** `Router(config-if)# interface gigabitethernet 1/0/0.2`	(Optional) Configures a subinterface and enters subinterface configuration mode.

Step 8	Repeat Step 4 and Step 5 to specify the VLAN tags to be terminated on the subinterface.
	
	Example:
	`Router(config-subif)# encapsulation dot1q 100 second-dot1q 100-199,201-600`
	
	Example:
	`Router(config-subif)# pppoe enable group vpn1`
		Step 4 enables the 802.1Q encapsulation of traffic on a specified subinterface in a VLAN.
		• Use the **second-dot1q** keyword and the *vlan-id* argument to specify the VLAN tags to be terminated on the subinterface.
		• In the example, an ambiguous Q-in-Q subinterface is configured because a range of inner VLAN IDs is specified.
		• Q-in-Q frames with an outer VLAN ID of 100 and an inner VLAN ID in the range of 100 to 199 or 201 to 600 will be terminated.
		Step 5 enables PPPoE sessions on the subinterface. The example specifies that the PPPoE profile, vpn1, will be used by PPPoE sessions on the subinterface.
		Note Step 5 is required for the Cisco 10000 series Internet router because it only supports PPPoEoQinQ traffic.

Step 9	**end** **Example:** `Router(config-subif)# end`	Exits subinterface configuration mode and returns to privileged EXEC mode.

Verifying the IEEE 802.1Q-in-Q VLAN Tag Termination

Perform this optional task to verify the configuration of the IEEE 802.1Q-in-Q VLAN Tag Termination feature.

SUMMARY STEPS

1. **enable**
2. **show running-config**

3. **show vlans dot1q** [**internal** | *interface-type interface-number.subinterface-number* [**detail**] | *outer-id* [*interface-type interface-number* | **second-dot1q** [*inner-id* | **any**]] [**detail**]]

DETAILED STEPS

Step 1 **enable**

Enables privileged EXEC mode. Enter your password if prompted.

```
Router> enable
```

Step 2 **show running-config**

Use this command to show the currently running configuration on the device. You can use delimiting characters to display only the relevant parts of the configuration.

The following shows the currently running configuration on a Cisco 7300 series router:

```
Router# show running-config

.
.
.

interface FastEthernet0/0.201
 encapsulation dot1Q 201
 ip address 10.7.7.5 255.255.255.252
!
interface FastEthernet0/0.401
 encapsulation dot1Q 401
 ip address 10.7.7.13 255.255.255.252
!
interface FastEthernet0/0.201999
 encapsulation dot1Q 201 second-dot1q any
 pppoe enable
!
interface FastEthernet0/0.2012001
 encapsulation dot1Q 201 second-dot1q 2001
 ip address 10.8.8.9 255.255.255.252
!
interface FastEthernet0/0.2012002
 encapsulation dot1Q 201 second-dot1q 2002
 ip address 10.8.8.13 255.255.255.252
!
interface FastEthernet0/0.4019999
 encapsulation dot1Q 401 second-dot1q 100-900,1001-2000
 pppoe enable
!
interface GigabitEthernet5/0.101
 encapsulation dot1Q 101
 ip address 10.7.7.1 255.255.255.252
!
interface GigabitEthernet5/0.301
 encapsulation dot1Q 301
 ip address 10.7.7.9 255.255.255.252
!
interface GigabitEthernet5/0.301999
 encapsulation dot1Q 301 second-dot1q any
 pppoe enable
!
interface GigabitEthernet5/0.1011001
 encapsulation dot1Q 101 second-dot1q 1001
 ip address 10.8.8.1 255.255.255.252
```

```
!
interface GigabitEthernet5/0.1011002
 encapsulation dot1Q 101 second-dot1q 1002
 ip address 10.8.8.5 255.255.255.252
!
interface GigabitEthernet5/0.1019999
 encapsulation dot1Q 101 second-dot1q 1-1000,1003-2000
 pppoe enable

.
.
.
```

The following shows the currently running configuration on a Cisco 10000 series Internet router:

```
Router# show running-config

.
.
.

interface FastEthernet1/0/0.201
 encapsulation dot1Q 201
 ip address 10.7.7.5 255.255.255.252
!
interface FastEthernet1/0/0.401
 encapsulation dot1Q 401
 ip address 10.7.7.13 255.255.255.252
!
interface FastEthernet1/0/0.201999
 encapsulation dot1Q 201 second-dot1q any
 pppoe enable
!
interface FastEthernet1/0/0.4019999
 encapsulation dot1Q 401 second-dot1q 100-900,1001-2000
 pppoe enable
!
interface GigabitEthernet5/0/0.101
 encapsulation dot1Q 101
 ip address 10.7.7.1 255.255.255.252
!
interface GigabitEthernet5/0/0.301
 encapsulation dot1Q 301
 ip address 10.7.7.9 255.255.255.252
!
interface GigabitEthernet5/0/0.301999
 encapsulation dot1Q 301 second-dot1q any
 pppoe enable
!
interface GigabitEthernet5/0/0.1019999
 encapsulation dot1Q 101 second-dot1q 1-1000,1003-2000
 pppoe enable

.
.
.
```

Step 3 **show vlans dot1q** [**internal** | *interface-type interface-number***.***subinterface-number* [**detail**] | *outer-id* [*interface-type interface-number* | **second-dot1q** [*inner-id* | **any**]] [**detail**]]

Use this command to show the statistics for all the 802.1Q VLAN IDs. In this example, only the outer VLAN ID is displayed.

Note The **show vlans dot1q command is not supported on the Cisco 10000 series Internet router.**

```
Router# show vlans dot1q

Total statistics for 802.1Q VLAN 1:
   441 packets, 85825 bytes input
   1028 packets, 69082 bytes output
Total statistics for 802.1Q VLAN 101:
   5173 packets, 510384 bytes input
   3042 packets, 369567 bytes output
Total statistics for 802.1Q VLAN 201:
   1012 packets, 119254 bytes input
   1018 packets, 120393 bytes output
Total statistics for 802.1Q VLAN 301:
   3163 packets, 265272 bytes input
   1011 packets, 120750 bytes output
Total statistics for 802.1Q VLAN 401:
   1012 packets, 119254 bytes input
   1010 packets, 119108 bytes output
```

Monitoring and Maintaining VLAN Subinterfaces

Use the following task to determine whether a VLAN is a native VLAN.

SUMMARY STEPS

1. enable
2. configure terminal
3. show vlans

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**show vlans** **Example:** `Router# show vlans`	Displays VLAN subinterfaces.

Example

The following is sample output from the **show vlans** command indicating a native VLAN and a bridged group:

```
Router# show vlans

Virtual LAN ID:  1 (IEEE 802.1Q Encapsulation)

   vLAN Trunk Interface:   FastEthernet1/0/2

 This is configured as native Vlan for the following interface(s) :

FastEthernet1/0/2

   Protocols Configured:   Address: Received:        Transmitted:

Virtual LAN ID:  100 (IEEE 802.1Q Encapsulation)

   vLAN Trunk Interface:   FastEthernet1/0/2.1

   Protocols Configured:   Address: Received:        Transmitted:

        Bridging        Bridge Group 1 0                   0
```

The following is sample output from the **show vlans** command that shows the traffic count on Fast Ethernet subinterfaces:

```
Router# show vlans

Virtual LAN ID:  2 (IEEE 802.1Q Encapsulation)

    vLAN Trunk Interface:   FastEthernet5/0.1

    Protocols Configured:   Address:              Received:        Transmitted:
           IP               172.16.0.3                   16               92129

Virtual LAN ID:  3 (IEEE 802.1Q Encapsulation)

    vLAN Trunk Interface:   Ethernet6/0/1.1
```

```
    Protocols Configured:   Address:              Received:        Transmitted:
           IP              172.20.0.3                 1558               1521

Virtual LAN ID:  4 (Inter Switch Link Encapsulation)

    vLAN Trunk Interface:   FastEthernet5/0.2

    Protocols Configured:   Address:              Received:        Transmitted:
           IP              172.30.0.3                    0                  7
```

Configuration Examples for Configuring Routing Between VLANs

This section provides the following configuration example:

- Single Range Configuration: Example, page 52
- ISL Encapsulation Configuration: Examples, page 53
- Routing IEEE 802.10 Configuration: Example, page 62
- IEEE 802.1Q Encapsulation Configuration: Examples, page 63
- Configuring IEEE 802.1Q-in-Q VLAN Tag Termination: Example, page 67

Single Range Configuration: Example

The following example configures the Fast Ethernet subinterfaces within the range 5/1.1 and 5/1.4 and applies the following VLAN IDs to those subinterfaces:

Fast Ethernet5/1.1 = VLAN ID 301 (*vlan-id*)

Fast Ethernet5/1.2 = VLAN ID 302 (*vlan-id* = 301 + 2 – 1 = 302)

Fast Ethernet5/1.3 = VLAN ID 303 (*vlan-id* = 301 + 3 – 1 = 303)

Fast Ethernet5/1.4 = VLAN ID 304 (*vlan-id* = 301 + 4 – 1 = 304)

```
Router(config)# interface range fastethernet5/1.1 - fastethernet5/1.4
Router(config-if)# encapsulation dot1Q 301
Router(config-if)# no shutdown
Router(config-if)#
*Oct  6 08:24:35: %LINK-3-UPDOWN: Interface FastEthernet5/1.1, changed state to up
*Oct  6 08:24:35: %LINK-3-UPDOWN: Interface FastEthernet5/1.2, changed state to up
*Oct  6 08:24:35: %LINK-3-UPDOWN: Interface FastEthernet5/1.3, changed state to up
*Oct  6 08:24:35: %LINK-3-UPDOWN: Interface FastEthernet5/1.4, changed state to up
*Oct  6 08:24:36: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet5/1.1,
changed state to up
*Oct  6 08:24:36: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet5/1.2,
changed state to up
*Oct  6 08:24:36: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet5/1.3,
changed state to up
*Oct  6 08:24:36: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet5/1.4,
changed state to up
```

ISL Encapsulation Configuration: Examples

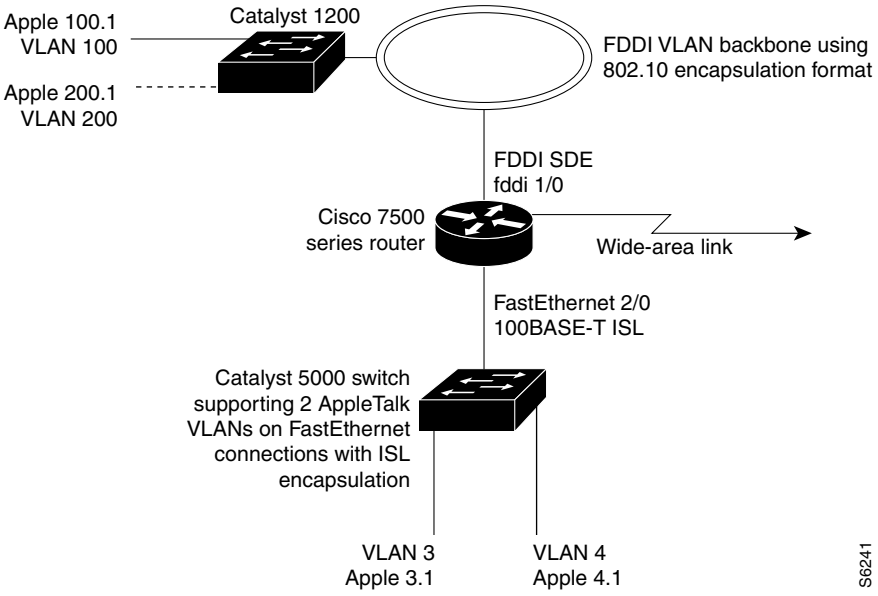
This section provides the following configuration examples for each of the protocols described in this chapter:

- AppleTalk Routing over ISL Configuration: Example, page 53
- Banyan VINES Routing over ISL Configuration: Example, page 54
- DECnet Routing over ISL Configuration: Example, page 54
- HSRP over ISL Configuration: Example, page 54
- IP Routing with RIF Between TrBRF VLANs: Example, page 56
- IP Routing Between a TRISL VLAN and an Ethernet ISL VLAN: Example, page 57
- IPX Routing over ISL Configuration: Example, page 58
- IPX Routing on FDDI Interfaces with SDE: Example, page 59
- Routing with RIF Between a TRISL VLAN and a Token Ring Interface: Example, page 59
- VIP Distributed Switching over ISL Configuration: Example, page 60
- XNS Routing over ISL Configuration: Example, page 61
- CLNS Routing over ISL Configuration: Example, page 62
- IS-IS Routing over ISL Configuration: Example

AppleTalk Routing over ISL Configuration: Example

The configuration example illustrated in Figure 84 shows AppleTalk being routed between different ISL and IEEE 802.10 VLAN encapsulating subinterfaces.

Figure 84 Routing AppleTalk over VLAN Encapsulations



As shown in Figure 84, AppleTalk traffic is routed to and from switched VLAN domains 3, 4, 100, and 200 to any other AppleTalk routing interface. This example shows a sample configuration file for the Cisco 7500 series router with the commands entered to configure the network shown in Figure 84.

Cisco 7500 Router Configuration

```
!
appletalk routing
interface Fddi 1/0.100
 encapsulation sde 100
 appletalk cable-range 100-100 100.2
 appletalk zone 100
!
interface Fddi 1/0.200
 encapsulation sde 200
 appletalk cable-range 200-200 200.2
 appletalk zone 200
!
interface FastEthernet 2/0.3
 encapsulation isl 3
 appletalk cable-range 3-3 3.2
 appletalk zone 3
!
interface FastEthernet 2/0.4
 encapsulation isl 4
 appletalk cable-range 4-4 4.2
 appletalk zone 4
!
```

Banyan VINES Routing over ISL Configuration: Example

To configure routing of the Banyan VINES protocol over ISL trunks, you need to define ISL as the encapsulation type. This example shows Banyan VINES configured to be routed over an ISL trunk:

```
vines routing
interface fastethernet 0.1
 encapsulation isl 100
 vines metric 2
```

DECnet Routing over ISL Configuration: Example

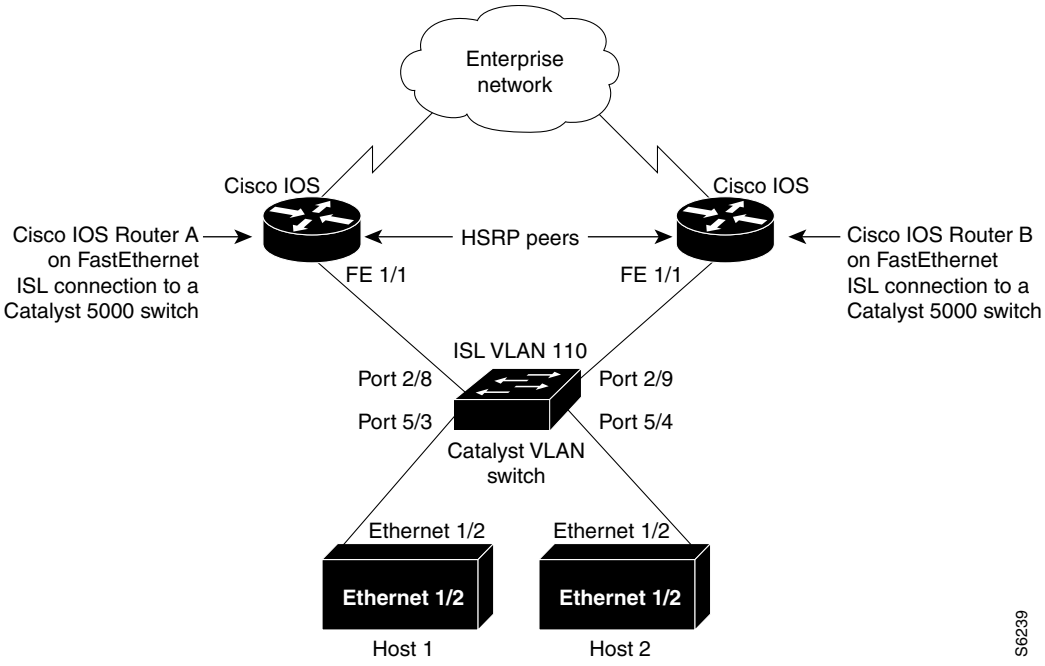
To configure routing the DECnet protocol over ISL trunks, you need to define ISL as the encapsulation type. This example shows DECnet configured to be routed over an ISL trunk:

```
decnet routing 2.1
interface fastethernet 1/0.1
 encapsulation isl 200
 decnet cost 4
```

HSRP over ISL Configuration: Example

The configuration example shown in Figure 85 shows HSRP being used on two VLAN routers sending traffic to and from ISL VLANs through a Catalyst 5000 switch. Each router forwards its own traffic and acts as a standby for the other.

Figure 85 Hot Standby Router Protocol Sample Configuration



The topology shown in Figure 85 shows a Catalyst VLAN switch supporting Fast Ethernet connections to two routers running HSRP. Both routers are configured to route HSRP over ISLs.

The standby conditions are determined by the standby commands used in the configuration. Traffic from Host 1 is forwarded through Router A. Because the priority for the group is higher, Router A is the active router for Host 1. Because the priority for the group serviced by Host 2 is higher in Router B, traffic from Host 2 is forwarded through Router B, making Router B its active router.

In the configuration shown in Figure 85, if the active router becomes unavailable, the standby router assumes active status for the additional traffic and automatically routes the traffic normally handled by the router that has become unavailable.

Host 1 Configuration

```
interface Ethernet 1/2
 ip address 10.1.1.25 255.255.255.0
 ip route 0.0.0.0 0.0.0.0 10.1.1.101
```

Host 2 Configuration

```
interface Ethernet 1/2
 ip address 10.1.1.27 255.255.255.0
 ip route 0.0.0.0 0.0.0.0 10.1.1.102
!
```

Router A Configuration

```
interface FastEthernet 1/1.110
 encapsulation isl 110
 ip address 10.1.1.2 255.255.255.0
 standby 1 ip 10.1.1.101
 standby 1 preempt
 standby 1 priority 105
 standby 2 ip 10.1.1.102
 standby 2 preempt
```

```
!
end

!
```

Router B Configuration

```
interface FastEthernet 1/1.110
 encapsulation isl 110
 ip address 10.1.1.3 255.255.255.0
 standby 1 ip 10.1.1.101
 standby 1 preempt
 standby 2 ip 10.1.1.102
 standby 2 preempt
 standby 2 priority 105
router igrp 1
!
network 10.1.0.0
network 10.2.0.0
!
```

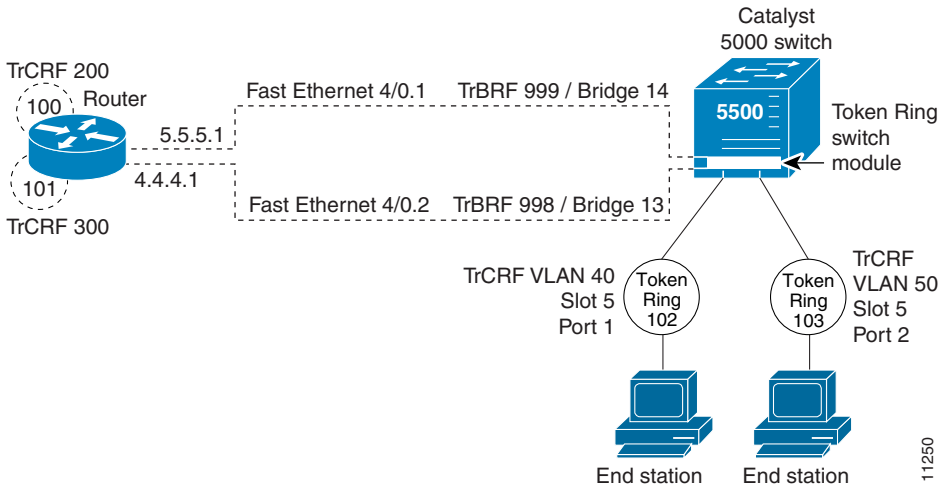
VLAN Switch Configuration

```
set vlan 110 5/4
set vlan 110 5/3
set trunk 2/8 110
set trunk 2/9 110
```

IP Routing with RIF Between TrBRF VLANs: Example

Figure 86 shows IP routing with RIF between two TrBRF VLANs.

Figure 86 IP Routing with RIF Between TrBRF VLANs



The following is the configuration for the router:

```
interface FastEthernet4/0.1
  ip address 10.5.5.1 255.255.255.0
  encapsulation tr-isl trbrf-vlan 999 bridge-num 14
  multiring trcrf-vlan 200 ring 100
  multiring all
!
```

```
 interface FastEthernet4/0.2
 ip address 10.4.4.1 255.255.255.0
 encapsulation tr-isl trbrf-vlan 998 bridge-num 13
 multiring trcrf-vlan 300 ring 101
 multiring all
```

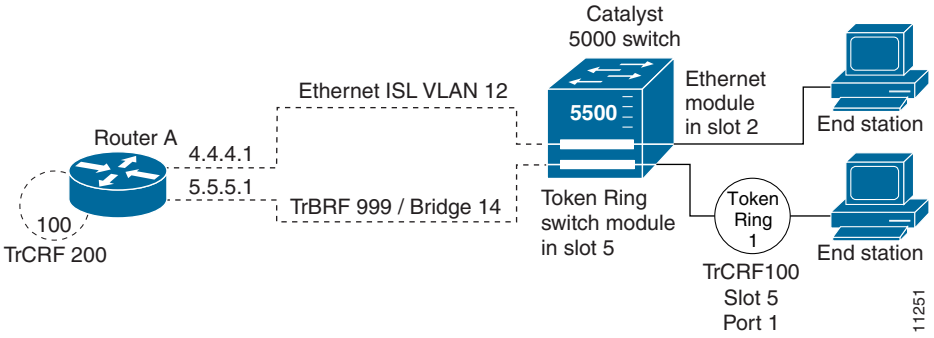
The following is the configuration for the Catalyst 5000 switch with the Token Ring switch module in slot 5. In this configuration, the Token Ring port 102 is assigned with TrCRF VLAN 40 and the Token Ring port 103 is assigned with TrCRF VLAN 50:

```
#vtp
set vtp domain trisl
set vtp mode server
set vtp v2 enable
#drip
set set tokenring reduction enable
set tokenring distrib-crf disable
#vlans
set vlan 999 name trbrf type trbrf bridge 0xe stp ieee
set vlan 200 name trcrf200 type trcrf parent 999 ring 0x64 mode srb
set vlan 40 name trcrf40 type trcrf parent 999 ring 0x66 mode srb
set vlan 998 name trbrf type trbrf bridge 0xd stp ieee
set vlan 300 name trcrf300 type trcrf parent 998 ring 0x65 mode srb
set vlan 50 name trcrf50 type trcrf parent 998 ring 0x67 mode srb
#add token port to trcrf 40
set vlan 40   5/1
#add token port to trcrf 50
set vlan 50   5/2
set trunk 1/2 on
```

IP Routing Between a TRISL VLAN and an Ethernet ISL VLAN: Example

Figure 87 shows IP routing between a TRISL VLAN and an Ethernet ISL VLAN.

Figure 87 IP Routing Between a TRISL VLAN and an Ethernet ISL VLAN



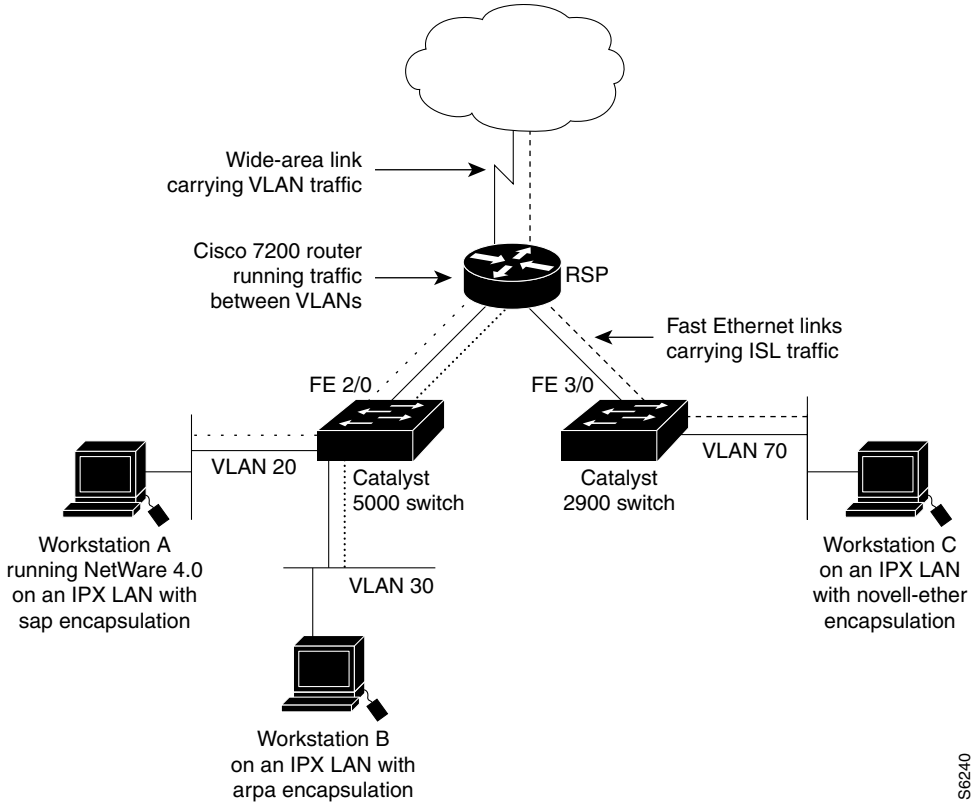
The following is the configuration for the router:

```
interface FastEthernet4/0.1
 ip address 10.5.5.1 255.255.255.0
 encapsulation tr-isl trbrf-vlan 999 bridge-num 14
 multiring trcrf-vlan 20 ring 100
 multiring all
!
interface FastEthernet4/0.2
 ip address 10.4.4.1 255.255.255.0
 encapsulation isl 12
```

IPX Routing over ISL Configuration: Example

Figure 88 shows IPX interior encapsulations configured over ISL encapsulation in VLAN configurations. Note that three different IPX encapsulation formats are used. VLAN 20 uses SAP encapsulation, VLAN 30 uses ARPA, and VLAN 70 uses novell-ether encapsulation. Prior to the introduction of this feature, only the default encapsulation format, "novell-ether," was available for routing IPX over ISL links in VLANs.

Figure 88 Configurable IPX Encapsulations Routed over ISL in VLAN Configurations



VLAN 20 Configuration

```
ipx routing
interface FastEthernet 2/0
 no shutdown
interface FastEthernet 2/0.20
 encapsulation isl 20
 ipx network 20 encapsulation sap
```

VLAN 30 Configuration

```
ipx routing
interface FastEthernet 2/0
 no shutdown
interface FastEthernet 2/0.30
 encapsulation isl 30
 ipx network 30 encapsulation arpa
```

VLAN 70 Configuration

```
ipx routing
interface FastEthernet 3/0
 no shutdown
interface Fast3/0.70
 encapsulation isl 70
 ipx network 70 encapsulation novell-ether
```

IPX Routing on FDDI Interfaces with SDE: Example

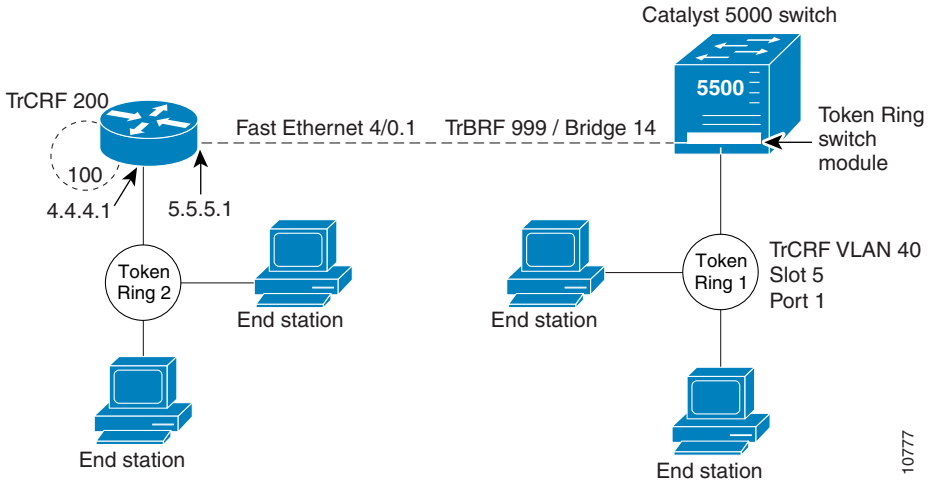
The following example enables IPX routing on FDDI interfaces 0.2 and 0.3 with SDE. On FDDI interface 0.2, the encapsulation type is SNAP. On FDDI interface 0.3, the encapsulation type is Novell's FDDI_RAW.

```
ipx routing

interface fddi 0.2 enc sde 2
 ipx network f02 encapsulation snap

interface fddi 0.3 enc sde 3
 ipx network f03 encapsulation novell-fddi
```

Routing with RIF Between a TRISL VLAN and a Token Ring Interface: Example

Figure 89 shows routing with RIF between a TRISL VLAN and a Token Ring interface.

Figure 89 Routing with RIF Between a TRISL VLAN and a Token Ring Interface



The following is the configuration for the router:

```
source-bridge ring-group 100
!
interface TokenRing 3/1
  ip address 10.4.4.1 255.255.255.0
!
interface FastEthernet4/0.1
  ip address 10.5.5.1 255.255.255.0
  encapsulation tr-isl trbrf 999 bridge-num 14
  multiring trcrf-vlan 200 ring-group 100
  multiring all
```

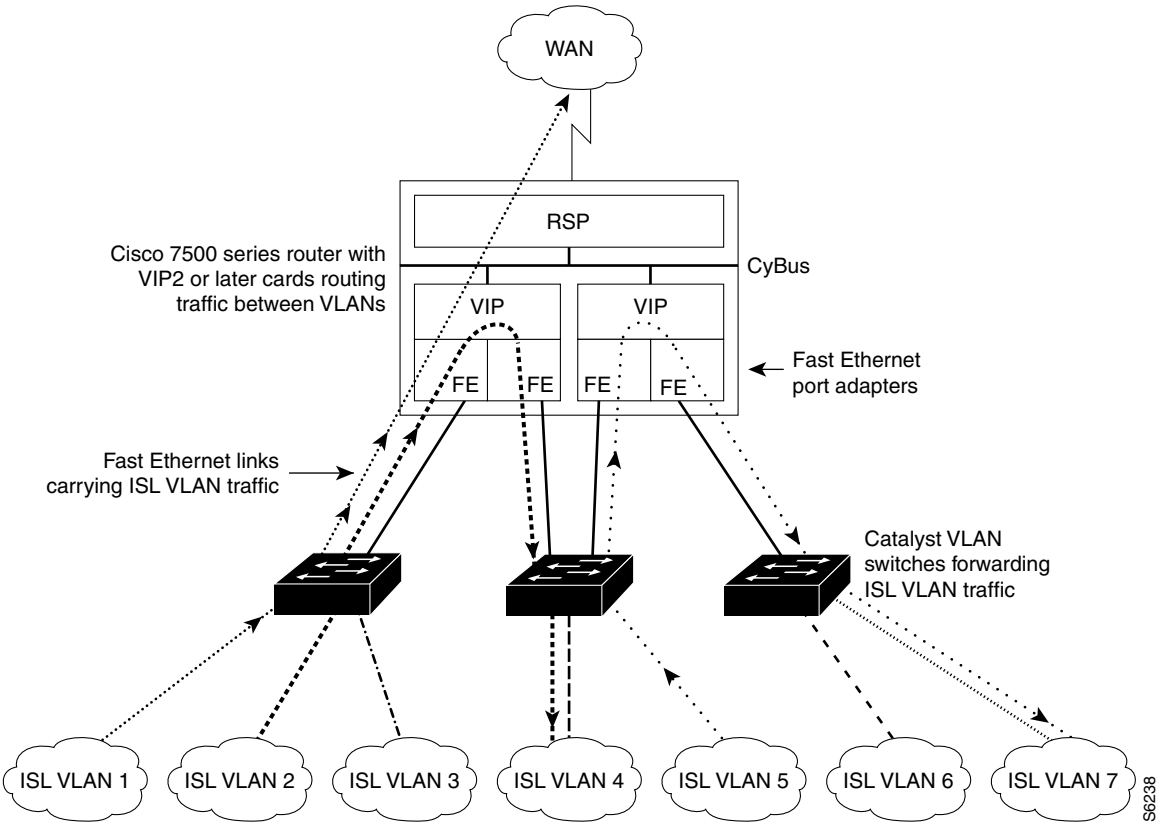
The following is the configuration for the Catalyst 5000 switch with the Token Ring switch module in slot 5. In this configuration, the Token Ring port 1 is assigned to the TrCRF VLAN 40:

```
#vtp
set vtp domain trisl
set vtp mode server
set vtp v2 enable
#drip
set set tokenring reduction enable
set tokenring distrib-crf disable
#vlans
set vlan 999 name trbrf type trbrf bridge 0xe stp ieee
set vlan 200 name trcrf200 type trcrf parent 999 ring 0x64 mode srt
set vlan 40 name trcrf40 type trcrf parent 999 ring 0x1 mode srt
#add token port to trcrf 40
set vlan 40   5/1
set trunk 1/2 on
```

VIP Distributed Switching over ISL Configuration: Example

Figure 90 shows a topology in which Catalyst VLAN switches are connected to routers forwarding traffic from a number of ISL VLANs. With the VIP distributed ISL capability in the Cisco 7500 series router, each VIP card can route ISL-encapsulated VLAN IP traffic. The inter-VLAN routing capacity is increased linearly by the packet-forwarding capability of each VIP card.

Figure 90 VIP Distributed ISL VLAN Traffic



In Figure 90, the VIP cards forward the traffic between ISL VLANs or any other routing interface. Traffic from any VLAN can be routed to any of the other VLANs, regardless of which VIP card receives the traffic.

These commands show the configuration for each of the VLANs shown in Figure 90:

```
interface FastEthernet1/0/0
 ip address 10.1.1.1 255.255.255.0
 ip route-cache distributed
 full-duplex

interface FastEthernet1/0/0.1
 ip address 10.1.1.1 255.255.255.0
 encapsulation isl 1

interface FastEthernet1/0/0.2
 ip address 10.1.2.1 255.255.255.0
 encapsulation isl 2

interface FastEthernet1/0/0.3
 ip address 10.1.3.1 255.255.255.0
 encapsulation isl 3

interface FastEthernet1/1/0
 ip route-cache distributed
 full-duplex

interface FastEthernet1/1/0.1
 ip address 172.16.1.1 255.255.255.0
 encapsulation isl 4

interface Fast Ethernet 2/0/0
 ip address 10.1.1.1 255.255.255.0
 ip route-cache distributed
 full-duplex

interface FastEthernet2/0/0.5
 ip address 10.2.1.1 255.255.255.0
 encapsulation isl 5

interface FastEthernet2/1/0
 ip address 10.3.1.1 255.255.255.0
 ip route-cache distributed
 full-duplex

interface FastEthernet2/1/0.6
 ip address 10.4.6.1 255.255.255.0
 encapsulation isl 6

interface FastEthernet2/1/0.7
 ip address 10.4.7.1 255.255.255.0
 encapsulation isl 7
```

XNS Routing over ISL Configuration: Example

To configure routing of the XNS protocol over ISL trunks, you need to define ISL as the encapsulation type. This example shows XNS configured to be routed over an ISL trunk:

```
xns routing 0123.4567.adcb
interface fastethernet 1/0.1
 encapsulation isl 100
 xns network 20
```

CLNS Routing over ISL Configuration: Example

To configure routing of the CLNS protocol over ISL trunks, you need to define ISL as the encapsulation type. This example shows CLNS configured to be routed over an ISL trunk:

```
clns routing
interface fastethernet 1/0.1
 encapsulation isl 100
 clns enable
```

IS-IS Routing over ISL Configuration: Example

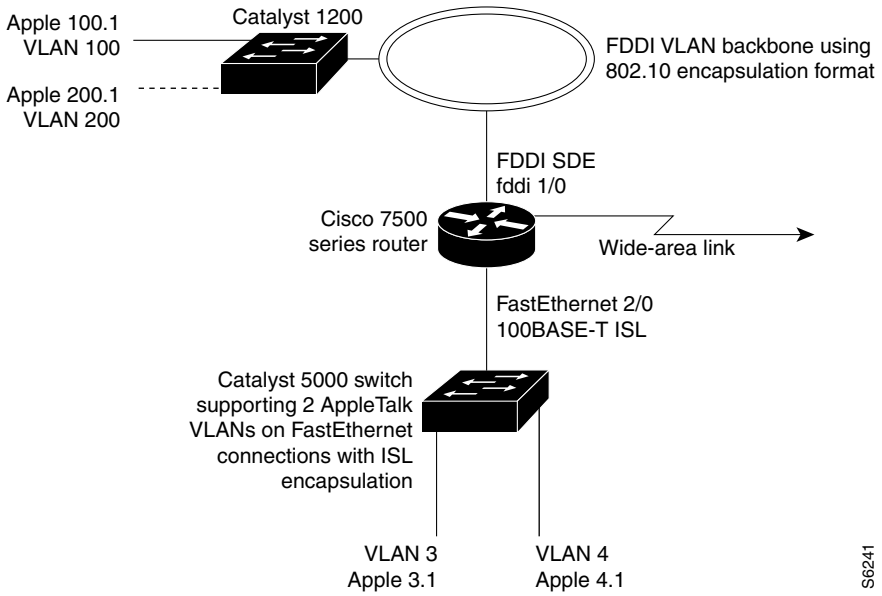
To configure IS-IS routing over ISL trunks, you need to define ISL as the encapsulation type. This example shows IS-IS configured over an ISL trunk:

```
isis routing test-proc2
net 49.0001.0002.aaaa.aaaa.aaaa.00
interface fastethernet 2.0
 encapsulation isl 101
 clns router is-is test-proc2
```

Routing IEEE 802.10 Configuration: Example

The configuration example shown in Figure 91 shows AppleTalk being routed between different ISL and IEEE 802.10 VLAN encapsulating subinterfaces.

Figure 91 Routing AppleTalk over VLAN encapsulations



As shown in Figure 91, AppleTalk traffic is routed to and from switched VLAN domains 3, 4, 100, and 200 to any other AppleTalk routing interface. This example shows a sample configuration file for the Cisco 7500 series router with the commands entered to configure the network shown in Figure 91.

Cisco 7500 Router Configuration

```
!
interface Fddi 1/0.100
 encapsulation sde 100
 appletalk cable-range 100-100 100.2
 appletalk zone 100
!
interface Fddi 1/0.200
 encapsulation sde 200
 appletalk cable-range 200-200 200.2
 appletalk zone 200
!
interface FastEthernet 2/0.3
 encapsulation isl 3
 appletalk cable-range 3-3 3.2
 appletalk zone 3
!
interface FastEthernet 2/0.4
 encapsulation isl 4
 appletalk cable-range 4-4 4.2
 appletalk zone 4
!
```

IEEE 802.1Q Encapsulation Configuration: Examples

Configuration examples for each protocols are provided in the following sections:

- !Configuring AppleTalk over IEEE 802.1Q: Example, page 63
- Configuring IP Routing over IEEE 802.1Q: Example, page 63
- Configuring IPX Routing over IEEE 802.1Q: Example, page 64
- VLAN 100 for Bridge Group 1 with Default VLAN1: Example, page 64
- VLAN 20 for Bridge Group 1 with Native VLAN: Example, page 64
- VLAN ISL or IEEE 802.1Q Routing: Example, page 64
- VLAN IEEE 802.1Q Bridging: Example, page 65
- VLAN IEEE 802.1Q IRB: Example, page 66

Configuring AppleTalk over IEEE 802.1Q: Example

This configuration example shows AppleTalk being routed on VLAN 100:

```
!
appletalk routing
!
interface fastethernet 4/1.100
  encapsulation dot1q 100
  appletalk cable-range 100-100 100.1
  appletalk zone eng
!
```

Configuring IP Routing over IEEE 802.1Q: Example

This configuration example shows IP being routed on VLAN 101:

```
!
```

```
ip routing
!
interface fastethernet 4/1.101
  encapsulation dot1q 101
  ip addr 10.0.0.11 255.0.0.0
!
```

Configuring IPX Routing over IEEE 802.1Q: Example

This configuration example shows IPX being routed on VLAN 102:

```
!
ipx routing
!
interface fastethernet 4/1.102
  encapsulation dot1q 102
  ipx network 100
!
```

VLAN 100 for Bridge Group 1 with Default VLAN1: Example

The following example configures VLAN 100 for bridge group 1 with a default VLAN1:

```
interface FastEthernet 4/1.100
encapsulation dot1q 1
bridge-group 1
```

VLAN 20 for Bridge Group 1 with Native VLAN: Example

The following example configures VLAN 20 for bridge group 1 as a native VLAN:

```
interface FastEthernet 4/1.100
encapsulation dot1q 20 native
bridge-group 1
```

VLAN ISL or IEEE 802.1Q Routing: Example

The following example configures VLAN ISL or IEEE 802.10 routing:

```
ipx routing
appletalk routing
!
interface Ethernet 1
ip address 10.1.1.1 255.255.255.0
appletalk cable-range 1-1 1.1
appletalk zone 1
ipx network 10 encapsulation snap
!
router igrp 1
network 10.1.0.0
!
end
!
#Catalyst5000
!
set VLAN 110 2/1
set VLAN 120 2/2
!
set trunk 1/1 110,120
# if 802.1Q, set trunk 1/1 nonegotiate 110, 120
```

```
!
end
!

ipx routing
appletalk routing
!
interface FastEthernet 1/1.110
encapsulation isl 110
!if 802.1Q, encapsulation dot1Q 110
ip address 10.1.1.2 255.255.255.0
appletalk cable-range 1.1 1.2
appletalk zone 1
ipx network 110 encapsulation snap
!
interface FastEthernet 1/1.120
encapsulation isl 120
!if 802.1Q, encapsulation dot1Q 120
ip address 10.2.1.2 255.255.255.0
appletalk cable-range 2-2 2.2
appletalk zone 2
ipx network 120 encapsulation snap
!
router igrp 1
network 10.1.0.0
network 10.2.1.0.0
!
end
!

ipx routing
appletalk routing
!
interface Ethernet 1
ip address 10.2.1.3 255.255.255.0
appletalk cable-range 2-2 2.3
appletalk zone 2
ipx network 120 encapsulation snap
!
router igrp 1
network 10.2.0.0
!
end
```

VLAN IEEE 802.1Q Bridging: Example

The following examples configures IEEE 802.1Q bridging:

```
interface FastEthernet4/0
 no ip address
 no ip route-cache
 half-duplex
!
interface FastEthernet4/0.100
 encapsulation dot1Q 100
 no ip route-cache
 bridge-group 1
!
interface FastEthernet4/0.200
 encapsulation dot1Q 200 native
 no ip route-cache
 bridge-group 2
!
```

```
interface FastEthernet4/0.300
 encapsulation dot1Q 1
 no ip route-cache
 bridge-group 3
!
interface FastEthernet10/0
 no ip address
 no ip route-cache
 half-duplex
!
interface FastEthernet10/0.100
 encapsulation dot1Q 100
 no ip route-cache
 bridge-group 1
!
interface Ethernet11/3
 no ip address
 no ip route-cache
 bridge-group 2
!
interface Ethernet11/4
 no ip address
 no ip route-cache
 bridge-group 3
!
bridge 1 protocol ieee
bridge 2 protocol ieee
bridge 3 protocol ieee
```

VLAN IEEE 802.1Q IRB: Example

The following examples configures IEEE 802.1Q integrated routing and bridging:

```
ip cef
appletalk routing
ipx routing 0060.2f27.5980
!
bridge irb
!
interface TokenRing3/1
 no ip address
 ring-speed 16
 bridge-group 2
!
interface FastEthernet4/0
 no ip address
 half-duplex
!
interface FastEthernet4/0.100
 encapsulation dot1Q 100
 bridge-group 1
!
interface FastEthernet4/0.200
 encapsulation dot1Q 200
 bridge-group 2
!
interface FastEthernet10/0
ip address 10.3.1.10 255.255.255.0
 half-duplex
 appletalk cable-range 200-200 200.10
 appletalk zone irb
 ipx network 200
!
```

```
interface Ethernet11/3
 no ip address
 bridge-group 1
!
interface BVI 1
 ip address 10.1.1.11 255.255.255.0
 appletalk cable-range 100-100 100.11
 appletalk zone bridging
 ipx network 100
!
router rip
 network 10.0.0.0
 network 10.3.0.0
!
bridge 1 protocol ieee
 bridge 1 route appletalk
 bridge 1 route ip
 bridge 1 route ipx
bridge 2 protocol ieee
!
```

Configuring IEEE 802.1Q-in-Q VLAN Tag Termination: Example

Some ambiguous subinterfaces can use the **any** keyword for the inner VLAN ID specification. The **any** keyword represents any inner VLAN ID that is not explicitly configured on any other interface. In the following example, seven subinterfaces are configured with various outer and inner VLAN IDs.

Note The **any** keyword can be configured on only one subinterface of a specified physical interface and outer VLAN ID.

```
interface GigabitEthernet1/0/0.1
 encapsulation dot1q 100 second-dot1q 100

interface GigabitEthernet1/0/0.2
 encapsulation dot1q 100 second-dot1q 200

interface GigabitEthernet1/0/0.3
 encapsulation dot1q 100 second-dot1q 300-400,500-600

interface GigabitEthernet1/0/0.4
 encapsulation dot1q 100 second-dot1q any

interface GigabitEthernet1/0/0.5
 encapsulation dot1q 200 second-dot1q 50

interface GigabitEthernet1/0/0.6
 encapsulation dot1q 200 second-dot1q 1000-2000,3000-4000

interface GigabitEthernet1/0/0.7
 encapsulation dot1q 200 second-dot1q any
```

Table 40 shows which subinterfaces are mapped to different values of the outer and inner VLAN ID on Q-in-Q frames that come in on Gigabit Ethernet interface 1/0/0.

Table 40 Subinterfaces Mapped to Outer and Inner VLAN IDs for GE Interface 1/0/0

Outer VLAN ID	Inner VLAN ID	Subinterface mapped to
100	1 through 99	GigabitEthernet1/0/0.4
100	100	GigabitEthernet1/0/0.1
100	101 through 199	GigabitEthernet1/0/0.4
100	200	GigabitEthernet1/0/0.2
100	201 through 299	GigabitEthernet1/0/0.4
100	300 through 400	GigabitEthernet1/0/0.3
100	401 through 499	GigabitEthernet1/0/0.4
100	500 through 600	GigabitEthernet1/0/0.3
100	601 through 4095	GigabitEthernet1/0/0.4
200	1 through 49	GigabitEthernet1/0/0.7
200	50	GigabitEthernet1/0/0.5
200	51 through 999	GigabitEthernet1/0/0.7
200	1000 through 2000	GigabitEthernet1/0/0.6
200	2001 through 2999	GigabitEthernet1/0/0.7
200	3000 through 4000	GigabitEthernet1/0/0.6
200	4001 through 4095	GigabitEthernet1/0/0.7

A new subinterface is now configured:

```
interface GigabitEthernet1/0/0.8
 encapsulation dot1q 200 second-dot1q 200-600,900-999
```

Table 41 shows the changes made to the table for the outer VLAN ID of 200. Notice that subinterface 1/0/0.7 configured with the **any** keyword now has new inner VLAN ID mappings.

Table 41 Subinterfaces Mapped to Outer and Inner VLAN IDs for GE Interface 1/0/0—Changes Resulting from Configuring GE Subinterface 1/0/0.8

Outer VLAN ID	Inner VLAN ID	Subinterface mapped to
200	1 through 49	GigabitEthernet1/0/0.7
200	50	GigabitEthernet1/0/0.5
200	51 through 199	GigabitEthernet1/0/0.7
200	200 through 600	GigabitEthernet1/0/0.8
200	601 through 899	GigabitEthernet1/0/0.7
200	900 through 999	GigabitEthernet1/0/0.8
200	1000 through 2000	GigabitEthernet1/0/0.6
200	2001 through 2999	GigabitEthernet1/0/0.7
200	3000 through 4000	GigabitEthernet1/0/0.6
200	4001 through 4095	GigabitEthernet1/0/0.7

Additional References

The following sections provide references related to configuring a VLAN range.

Related Documents

Related Topic	Document Title
Configuring wide-area networking	*Cisco IOS Wide-Area Networking Configuration Guide*, Release 12.2
Commands used in configuring wide-area networking	*Cisco IOS Wide-Area Networking Command Reference*, Release 12.2
Configuring interface ranges	*Interface Range Specification*, new feature document for Cisco IOS Release 12.1(5)T
Commands using in Configuring Routing Between VLANs with IEEE 802.10 Encapsulation	Cisco IOS Release 12.4, *Cisco IOS Switching Services Command Reference*
Configuring AppleTalk	*Cisco IOS AppleTalk and Novell IPX Configuration Guide*
Commands using in Configuring Routing Between VLANs with IEEE 802.1Q Encapsulation	Cisco IOS Release 12.4, *Cisco IOS Switching Services Command Reference*
IP routing configuration	*Cisco IOS IP Routing Configuration Guide*
Interface commands: complete command syntax, command mode, defaults, usage guidelines, and examples	*Cisco IOS Interface and Hardware Component Command Reference*, *Release 12.3T*
Interface configuration examples	*Cisco IOS Interface and Hardware Component Configuration Guide*

Standards

Standard	Title
IEEE 802.10 standard	802.10 Virtual LANs

MIBs

MIB	MIBs Link
• None	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFC	Title
None	—

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/techsupport

Feature Information for Routing Between VLANs

Table 42 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in Cisco IOS Releases 12.0(3)S or a later release appear in the table.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Cisco IOS software images are specific to a Cisco IOS software release, a feature set, and a platform. Use Cisco Feature Navigator to find information about platform support and Cisco IOS software image support. Access Cisco Feature Navigator at http://www.cisco.com/go/fn. You must have an account on Cisco.com. If you do not have an account or have forgotten your username or password, click **Cancel** at the login dialog box and follow the instructions that appear.

Note Table 42 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 42 Feature Information for Routing Between VLANs

Feature Name	Releases	Feature Information
IEEE 802.1Q-in-Q VLAN Tag Termination	12.0(28)S, 12.3(7(X17, 12.0(32)S1, 12.2(31)SB	IEEE 802.1Q-in-Q VLAN Tag Termination simply adds another layer of IEEE 802.1Q tag (called “metro tag” or “PE-VLAN”) to the 802.1Q tagged packets that enter the network. The purpose is to expand the VLAN space by tagging the tagged packets, thus producing a “double-tagged” frame. The expanded VLAN space allows the service provider to provide certain services, such as Internet access on specific VLANs for specific customers, and yet still allows the service provider to provide other types of services for their other customers on other VLANs.
VLAN Range		Using the VLAN Range feature, you can group VLAN subinterfaces together so that any command entered in a group applies to every subinterface within the group. This capability simplifies configurations and reduces command parsing.
	12.0(7)XE	The **interface range** command was introduced.

Table 42 Feature Information for Routing Between VLANs

Feature Name	Releases	Feature Information
	12.1(5)T	The **interface range** command was integrated into Cisco IOS Release 12.1(5)T.
	12.2(2)DD	The **interface range** command was expanded to enable configuration of subinterfaces.
	12.2(4)B	The **interface range** command was integrated into Cisco IOS Release 12.2(4)B.
	12.2(8)T	The VLAN Range feature was integrated into Cisco IOS Release 12.2(8)T.
	12.2(13)T	This VLAN Range feature was integrated into Cisco IOS Release 12.2(13)T.

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Managed LAN Switch

The Managed LAN Switch feature enables the control of the four switch ports in Cisco 831, 836, and 837 routers. Each switch port is associated with a Fast Ethernet interface. The output of the command **show controllers fastEthernet** <*1-4*> displays the status of the selected switch port.

The Managed LAN Switch feature allows setting and display of the following parameters for each of the switch ports:

- Speed
- Duplex

It also allows display of the link state of a switch port—that is, whether a device is connected to that port or not.

Feature History for the Managed LAN Switch Feature

Release	Modification
12.3(2)XC	This feature modifies the output of the command **show controllers fastEthernet** <*1-4*> to show the status of switch port.

Finding Support Information for Platforms and Cisco IOS Software Images

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Contents

- Information About Managed LAN Switch, page 2
- How to Enable Managed LAN Switch, page 2
- Configuration Examples for Managed LAN Switch, page 4
- Additional References, page 4
- Command Reference, page 5

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Information About Managed LAN Switch

To configure the Managed LAN Switch feature, you should understand the following concept:

- LAN Switching, page 2

LAN Switching

A LAN is a high-speed, fault-tolerant data network that supplies connectivity to a group of computers, printers, and other devices that are in close proximity to each other, as in an office building, a school or a home. LANs offer computer users many advantages, including shared access to devices and applications, file exchange between connected users, and communication between users via electronic mail and other applications.

For more information about LAN switching, refer to the following URL:

http://www.cisco.com/en/US/tech/tk389/tech_topology_and_network_serv_and_protocol_suite_home.html

How to Enable Managed LAN Switch

This section contains the following procedure:

- Enabling Managed LAN Switch

Enabling Managed LAN Switch

To enable Managed LAN Switch, perform the following steps:

SUMMARY STEPS

1. **enable**
2. **interface fastEthernet**
3. **duplex** *auto*
4. **speed** *auto*
5. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**interface fastEthernet** *interface-number* **Example:** `Router(config)# interface fastEthernet`	Configures a Fast Ethernet interface and enters interface configuration mode.
Step 3	**duplex** *auto* **Example:** `Router(config-if)# duplex auto`	Enables LAN switching on the selected port with duplex setting in auto mode.
Step 4	**speed** *auto* **Example:** `Router(config-if)# speed auto`	Enables LAN switching on the selected port with speed setting in auto mode.
Step 5	**end** **Example:** `Router(config-if)# end`	Ends the current configuration session and returns to privileged EXEC mode.

Verifying Managed LAN Switch

To verify the Managed LAN Switch configuration, enter the **show controllers fastEthernet** <*1-4*> command in EXEC mode. The following sample output shows the status of switch port 1.

```
Router#show controllers fastEthernet 1
!
Interface FastEthernet1   MARVELL 88E6052
Link is DOWN
Port is undergoing Negotiation or Link down
Speed :Not set, Duplex :Not set
!
Switch PHY Registers:
~~~~~~~~~~~~~~~~~~~~

00 : 3100   01 : 7849   02 : 0141   03 : 0C1F   04 : 01E1
05 : 0000   06 : 0004   07 : 2001   08 : 0000   16 : 0130
17 : 0002   18 : 0000   19 : 0040   20 : 0000   21 : 0000
!
Switch Port Registers:
~~~~~~~~~~~~~~~~~~~~~
Port Status Register       [00] : 0800
Switch Identifier Register [03] : 0520
Port Control Register      [04] : 007F
Rx Counter Register        [16] : 000A
```

```
Tx Counter Register         [17] : 0008
!
```

Configuration Examples for Managed LAN Switch

This section provides the following configuration example:

- Enabling Managed LAN Switch: Example

Enabling Managed LAN Switch: Example

The following example shows the Managed LAN Switch configured with duplex set to auto and full, speed set to auto and 100:

```
configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
interface fastEthernet1
no ip address
duplex auto
speed auto
!
interface fastEthernet2
no ip address
duplex full  <----------------      duplex setting of port 2
speed 100 <-----------------    speed setting of port 2
!
interface fastEthernet3
no ip address
shutdown   <--------------- shutting port 3
duplex auto
speed auto
!
interface fastEthernet4
no ip address
duplex auto
speed auto
!
```

Additional References

The following sections provide references related to the Managed LAN Switch feature.

Related Documents

Related Topic	Document Title
Cisco IOS Release 12.3 Configuration Guides and Command References	*Cisco IOS Release 12.3 Configuration Guides and Command References*

Standards

Standards	Title
None	—

MIBs

MIBs	MIBs Link
• None	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFCs	Title
None	—

Technical Assistance

Description	Link
Technical Assistance Center (TAC) home page, containing 30,000 pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/public/support/tac/home.shtml

Command Reference

The following commands are introduced or modified in the feature or features documented in this module. For information about these commands, see the *Cisco IOS LAN Switching Command Reference* at http://www.cisco.com/en/US/docs/ios/lanswitch/command/reference/lsw_book.html. For information about all Cisco IOS commands, go to the Command Lookup Tool at http://tools.cisco.com/Support/CLILookup or to the *Cisco IOS Master Commands List*.

- **show controllers fastEthernet**

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Cisco HWIC-4ESW and HWIC-D-9ESW EtherSwitch Interface Cards

First Published: May 17, 2005
Last Updated: October 10, 2008

This document provides configuration tasks for the 4-port Cisco HWIC-4ESW and the 9-port Cisco HWIC-D-9ESW EtherSwitch high-speed WAN interface cards (HWICs) hardware feature supported on Cisco 1800 (modular), Cisco 2800, and Cisco 3800 series integrated services routers.

Cisco EtherSwitch HWICs are 10/100BASE-T Layer 2 Ethernet switches with Layer 3 routing capability. (Layer 3 routing is forwarded to the host and is not actually performed at the switch.) Traffic between different VLANs on a switch is routed through the router platform. Any one port on a Cisco EtherSwitch HWIC may be configured as a stacking port to link to another Cisco EtherSwitch HWIC or EtherSwitch network module in the same system. An optional power module can also be added to provide inline power for IP telephones. The HWIC-D-9ESW HWIC requires a double-wide card slot.

This hardware feature does not introduce any new or modified Cisco IOS commands.

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "Feature Information for the Cisco HWIC-4ESW and the Cisco HWIC-D-9ESW EtherSwitch Cards" section on page 116.

Finding Support Information for Platforms and Cisco IOS Software Images

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Contents

The following sections provide information about the Cisco EtherSwitch HWICs.

- Prerequisites for EtherSwitch HWICs, page 2
- Restrictions for EtherSwitch HWICs, page 2
- Information About EtherSwitch HWICs, page 3
- How to Configure EtherSwitch HWICs, page 5
- Configuration Examples for EtherSwitch HWICs, page 104
- Additional References, page 114

Prerequisites for EtherSwitch HWICs

The following are prerequisites to configuring EtherSwitch HWICs:

- Configuration of IP routing. (Refer to the *Cisco IOS IP Configuration Guide*.)
- Use of the Cisco IOS T release, beginning with Release 12.3(8)T4 or later for Cisco HWIC-4ESW and Cisco HWIC-D-9ESW support. (Refer to the Cisco IOS documentation.)

Restrictions for EtherSwitch HWICs

The following restrictions apply to the Cisco HWIC-4ESW and the Cisco HWIC-D-9ESW EtherSwitch HWICs:

- No more than two Ethernet Switch HWICs or network modules may be installed in a host router.

  Multiple Ethernet Switch HWICs or network modules installed in a host router will not act independently of each other. They must be stacked, as they will not work at all otherwise.
- The ports of a Cisco EtherSwitch HWIC must NOT be connected to the Fast Ethernet/Gigabit onboard ports of the router.
- There is no inline power on the ninth port (port 8) of the HWIC-D-9ESW card.
- There is no Auto MDIX support on the ninth port (port 8) of the HWIC-D-9ESW card when either **speed** or **duplex** is not set to **auto**.
- There is no support for online insertion/removal (OIR) of the EtherSwitch HWICs.
- When Ethernet Switches have been installed and configured in a host router, OIR of the CompactFlash memory card in the router must not occur. OIR of the CompactFlash memory card will compromise the configuration of the Ethernet Switches.
- VTP pruning is not supported.
- There is a limit of 200 secure MAC addresses per module that can be supported by an EtherSwitch HWIC.

Prerequisites for Installing Two Ethernet Switch Network Modules in a Single Chassis

A maximum of two Ethernet switch network modules can be installed in a single chassis. If two Ethernet switch network modules of any type are installed in the same chassis, the following configuration requirements must be met:

- Both Ethernet switch network modules must have an optional Gigabit Ethernet expansion board installed.
- An Ethernet crossover cable must be connected to the two Ethernet switch network modules using the optional Gigabit Ethernet expansion board ports.
- Intrachassis stacking for the optional Gigabit Ethernet expansion board ports must be configured. For information about intrachassis stacking configuration, see the 16- and 36-Port Ethernet Switch Module for Cisco 2600 Series, Cisco 3600 Series, and Cisco 3700 series feature document.

Note Without this configuration and connection, duplications will occur in the VLAN databases, and unexpected packet handling may occur.

Information About EtherSwitch HWICs

To configure the Cisco HWIC-4ESW and HWIC-D-9ESW EtherSwitch HWICs, you should understand the following concepts:

- VLANs, page 3
- Inline Power for Cisco IP Phones, page 4
- Layer 2 Ethernet Switching, page 4
- 802.1x Authentication, page 4
- Spanning Tree Protocol, page 4
- Cisco Discovery Protocol, page 4
- Switched Port Analyzer, page 4
- IGMP Snooping, page 4
- Storm Control, page 5
- Intrachassis Stacking, page 5
- Fallback Bridging, page 5

VLANs

For information on the concept of VLANs, refer to the material at this URL:

http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123t/123t_4/gt1636nm.htm#1047027

Inline Power for Cisco IP Phones

For information on the concept of inline power for Cisco IP phones, refer to the material at this URL:

http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123t/123t_4/gt1636nm.htm#1048439

Layer 2 Ethernet Switching

For information on the concept of Layer 2 Ethernet switching, refer to the material at this URL:

http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123t/123t_4/gt1636nm.htm#1048478

802.1x Authentication

For information on the concept of 802.1x authentication, refer to the material at this URL:

http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123t/123t_4/gt1636nm.htm#1051006

Spanning Tree Protocol

For information on the concept of Spanning Tree Protocol, refer to the material at this URL:

http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123t/123t_4/gt1636nm.htm#1048458

Cisco Discovery Protocol

For information on the concept of the Cisco Discovery Protocol, refer to the material at this URL:

http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123t/123t_4/gt1636nm.htm#1048498

Switched Port Analyzer

For information on the concept of switched port analyzer, refer to the material at this URL:

http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123t/123t_4/gt1636nm.htm#1053663

IGMP Snooping

For information on the concept of IGMP snooping, refer to the material at this URL:

http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123t/123t_4/gt1636nm.htm#1053727

Storm Control

For information on the concept of storm control, refer to the material at this URL:

http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123t/123t_4/gt1636nm.htm#1051018

Intrachassis Stacking

For information on the concept of intrachassis stacking, refer to the material at this URL:

http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123t/123t_4/gt1636nm.htm#1051061

Fallback Bridging

For information on the concept of fallback bridging, refer to the material at this URL:

http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123newft/123t/123t_4/gt1636nm.htm#1054833

How to Configure EtherSwitch HWICs

See the following sections for configuration tasks for the EtherSwitch HWICs.

- Configuring VLANs, page 6
- Configuring VLAN Trunking Protocol, page 10
- Configuring Layer 2 Interfaces, page 13
- Configuring 802.1x Authentication, page 23
- Configuring Spanning Tree, page 35
- Configuring MAC Table Manipulation, page 46
- Configuring Cisco Discovery Protocol, page 50
- Configuring the Switched Port Analyzer (SPAN), page 53
- Configuring Power Management on the Interface, page 56
- Configuring IP Multicast Layer 3 Switching, page 57
- Configuring IGMP Snooping, page 61
- Configuring Per-Port Storm Control, page 68
- Configuring Stacking, page 71
- Configuring Fallback Bridging, page 73
- Configuring Separate Voice and Data Subnets, page 88
- Managing the EtherSwitch HWIC, page 91

Configuring VLANs

This section describes how to configure VLANs on the switch and contains the following sections:

- Adding a VLAN Instance, page 6
- Deleting a VLAN Instance from the Database, page 8

Adding a VLAN Instance

A total of 15 VLANs can be supported by an EtherSwitch HWIC.

Follow the steps below to configure a Fast Ethernet interface as Layer 2 access.

SUMMARY STEPS

1. **enable**
2. **vlan database**
3. **vlan** *vlan_id*
4. **exit**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**vlan database** **Example:** `Router# vlan database`	Enters VLAN configuration mode.
Step 3	**vlan** *vlan_id* **Example:** `Router(vlan)# vlan 1`	Adds an Ethernet VLAN.
Step 4	**exit** **Example:** `Router(vlan)# exit`	Updates the VLAN database, propagates it throughout the administrative domain, and returns to privileged EXEC mode.

Verifying the VLAN Configuration

You can verify the VLAN configuration in VLAN database mode.

Use the **show** command in VLAN database mode to verify the VLAN configuration, as shown below:

```
Router(vlan)# show

  VLAN ISL Id: 1
  Name: default
```

```
Media Type: Ethernet
VLAN 802.10 Id: 100001
State: Operational
MTU: 1500
Translational Bridged VLAN: 1002
Translational Bridged VLAN: 1003

VLAN ISL Id: 2
Name: VLAN0002
Media Type: Ethernet
VLAN 802.10 Id: 100002
State: Operational
MTU: 1500

VLAN ISL Id: 3
Name: Red_VLAN
Media Type: Ethernet
VLAN 802.10 Id: 100003
State: Operational
MTU: 1500

VLAN ISL Id: 1002
Name: fddi-default
Media Type: FDDI
VLAN 802.10 Id: 101002
State: Operational
MTU: 1500
Bridge Type: SRB
Translational Bridged VLAN: 1
Translational Bridged VLAN: 1003

VLAN ISL Id: 1003
Name: token-ring-default
Media Type: Token Ring
VLAN 802.10 Id: 101003
State: Operational
MTU: 1500
Bridge Type: SRB
Ring Number: 0
Bridge Number: 1
Parent VLAN: 1005
Maximum ARE Hop Count: 7
Maximum STE Hop Count: 7
Backup CRF Mode: Disabled
Translational Bridged VLAN: 1
Translational Bridged VLAN: 1002

VLAN ISL Id: 1004
 Name: fddinet-default
Media Type: FDDI Net
VLAN 802.10 Id: 101004
State: Operational
MTU: 1500
Bridge Type: SRB
Bridge Number: 1
STP Type: IBM

VLAN ISL Id: 1005
Name: trnet-default
Media Type: Token Ring Net
VLAN 802.10 Id: 101005
State: Operational
MTU: 1500
Bridge Type: SRB
```

```
  Bridge Number: 1
  STP Type: IBM

Router(vlan)# exit

APPLY completed.
Exiting....
Router#
Router#
```

Enter the **show vlan-switch** command in EXEC mode using the Cisco IOS CLI to verify the VLAN configuration, as shown below.

```
Router# show vlan-switch

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/1/1, Fa0/1/2, Fa0/1/3, Fa0/1/4
                                                Fa0/1/5, Fa0/1/6, Fa0/1/7, Fa0/1/8
                                                Fa0/3/0, Fa0/3/2, Fa0/3/3, Fa0/3/4
                                                Fa0/3/5, Fa0/3/6, Fa0/3/7, Fa0/3/8
2    VLAN0002                         active    Fa0/1/0
3    Red_VLAN                         active
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active
VLAN Type  SAID       MTU   Parent RingNo BridgeNo Stp  BrdgMode Trans1 Trans2
---- ----- ---------- ----- ------ ------ -------- ---- -------- ------ ------
1    enet  100001     1500  -      -      -        -    -        1002   1003
2    enet  100002     1500  -      -      -        -    -        0      0
3    enet  100003     1500  -      -      -        -    -        0      0
1002 fddi  101002     1500  -      -      -        -    -        1      1003
1003 tr    101003     1500  1005   0      -        -    srb      1      1002
1004 fdnet 101004     1500  -      -      1        ibm  -        0      0
1005 trnet 101005     1500  -      -      1        ibm  -        0      0

Router#
```

Deleting a VLAN Instance from the Database

You cannot delete the default VLANs for the different media types: Ethernet VLAN 1 and FDDI or Token Ring VLANs 1002 to 1005.

Follow the steps below to delete a VLAN from the database.

SUMMARY STEPS

1. **enable**
2. **vlan database**
3. **no vlan** *vlan_id*
4. **exit**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**vlan database** **Example:** `Router# vlan database`	Enters VLAN configuration mode.
Step 3	**no vlan** *vlan_id* **Example:** `Router(vlan)# no vlan 1`	Deletes an Ethernet VLAN.
Step 4	**exit** **Example:** `Router(vlan)# exit`	Updates the VLAN database, propagates it throughout the administrative domain, and returns to privileged EXEC mode.

Verifying VLAN Deletion

You can verify that a VLAN has been deleted from the switch in VLAN database mode.

Use the **show** command in VLAN database mode to verify that a VLAN has been deleted from the switch, as shown in the following output example:

```
Router(vlan)# show

  VLAN ISL Id: 1
    Name: default
    Media Type: Ethernet
    VLAN 802.10 Id: 100001
    State: Operational
    MTU: 1500
    Translational Bridged VLAN: 1002
    Translational Bridged VLAN: 1003

  VLAN ISL Id: 1002
    Name: fddi-default
    Media Type: FDDI
    VLAN 802.10 Id: 101002
    State: Operational
    MTU: 1500
    Bridge Type: SRB
    Translational Bridged VLAN: 1
    Translational Bridged VLAN: 1003
<output truncated>

Router(vlan)#
```

Enter the **show vlan-switch brief** command in EXEC mode, using the Cisco IOS CLI to verify that a VLAN has been deleted from the switch, as shown in the following output example:

```
Router# show vlan-switch brief
```

```
VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/1/0, Fa0/1/1, Fa0/1/2
                                                Fa0/1/3, Fa0/1/4, Fa0/1/5
                                                Fa0/1/6, Fa0/1/7, Fa0/1/8
300  VLAN0300                         active
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active
Router#
```

Configuring VLAN Trunking Protocol

This section describes how to configure the VLAN Trunking Protocol (VTP) on an EtherSwitch HWIC, and contains the following tasks:

- Configuring a VTP Server, page 10
- Configuring a VTP Client, page 12
- Disabling VTP (VTP Transparent Mode), page 12
- Verifying VTP, page 13

Note VTP pruning is not supported by EtherSwitch HWICs.

Configuring a VTP Server

When a switch is in VTP server mode, you can change the VLAN configuration and have it propagate throughout the network.

Follow the steps below to configure the switch as a VTP server.

SUMMARY STEPS

1. **enable**
2. **vlan database**
3. **vtp server**
4. **vtp domain** *domain_name*
5. **vtp password** *password_value*
6. **exit**

DETAILED STEPS

Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**vlan database** **Example:** `Router# vlan database`	Enters VLAN configuration mode.
Step 3	**vtp server** **Example:** `Router(vlan)# vtp server`	Configures the switch as a VTP server.
Step 4	**vtp domain** *domain_name* **Example:** `Router(vlan)# vtp domain distantusers`	Defines the VTP domain name, which can be up to 32 characters long.
Step 5	**vtp password** *password_value* **Example:** `Router(vlan)# vtp password philadelphis`	(Optional) Sets a password, which can be from 8 to 64 characters long, for the VTP domain.
Step 6	**exit** **Example:** `Router(vlan)# exit`	Updates the VLAN database, propagates it throughout the administrative domain, exits VLAN configuration mode, and returns to privileged EXEC mode.

Configuring a VTP Client

When a switch is in VTP client mode, you cannot change the VLAN configuration on the switch. The client switch receives VTP updates from a VTP server in the management domain and modifies its configuration accordingly.

Follow the steps below to configure the switch as a VTP client.

SUMMARY STEPS

1. **enable**
2. **vlan database**
3. **vtp client**
4. **exit**

DETAILED STEPS

Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**vlan database** **Example:** `Router# vlan database`	Enters VLAN configuration mode.
Step 3	**vtp client** **Example:** `Router(vlan)# vtp client`	Configures the switch as a VTP client.
Step 4	**exit** **Example:** `Router(vlan)# exit`	Updates the VLAN database, propagates it throughout the administrative domain, exits VLAN configuration mode and returns to privileged EXEC mode.

Disabling VTP (VTP Transparent Mode)

When you configure the switch as VTP transparent, you disable VTP on the switch. A VTP transparent switch does not send VTP updates and does not act on VTP updates received from other switches.

Follow the steps below to disable VTP on the switch.

SUMMARY STEPS

1. **enable**
2. **vlan database**
3. **vtp transparent**
4. **exit**

DETAILED STEPS

Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**vlan database** **Example:** `Router# vlan database`	Enters VLAN configuration mode.
Step 3	**vtp transparent** **Example:** `Router(vlan)# vtp transparent`	Configures VTP transparent mode.
Step 4	**exit** **Example:** `Router(vlan)# exit`	Updates the VLAN database, propagates it throughout the administrative domain, exits VLAN configuration mode, and returns to privileged EXEC mode.

Verifying VTP

Use the **show vtp status** command to verify VTP status:

```
Router# show vtp status

VTP Version                     : 2
Configuration Revision          : 0
Maximum VLANs supported locally : 256
Number of existing VLANs        : 5
VTP Operating Mode              : Server
VTP Domain Name                 :
VTP Pruning Mode                : Disabled
VTP V2 Mode                     : Disabled
VTP Traps Generation            : Disabled
MD5 digest                      : 0xBF 0x86 0x94 0x45 0xFC 0xDF 0xB5 0x70
Configuration last modified by 0.0.0.0 at 0-0-00 00:00:00
Local updater ID is 1.3.214.25 on interface Fa0/0 (first interface found)
Router#
```

Configuring Layer 2 Interfaces

This section provides the following configuration information:

- Configuring a Range of Interfaces, page 14 (required)
- Defining a Range Macro, page 14 (optional)
- Configuring Layer 2 Optional Interface Features, page 15 (optional)

Configuring a Range of Interfaces

Use the following task to configure a range of interfaces.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface range {macro** *macro_name* **| FastEthernet** *interface-id* **[-** *interface-id***] | vlan** *vlan_ID***} [, FastEthernet** *interface-id* **[-** *interface-id***] | vlan** *vlan-ID***]**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface range** {**macro** *macro_name* | **FastEthernet** *interface-id* [**-** *interface-id*] | **vlan** *vlan-ID*} [**, FastEthernet** *interface-id* [- *interface-id*] | **vlan** *vlan-ID*] **Example:** `Router(config)# interface range FastEthernet 0/1/0 - 0/1/3`	Select the range of interfaces to be configured. • The space before the dash is required. For example, the command **interface range fastethernet** 0/<*slot*>**/0 -** 0/<*slot*>**/3** is valid; the command **interface range fastethernet** 0/<*slot*>**/0-**0/<*slot*>**/3** is not valid. • You can enter one macro or up to five comma-separated ranges. • Comma-separated ranges can include both VLANs and physical interfaces. • You are not required to enter spaces before or after the comma. • The **interface range** command only supports VLAN interfaces that are configured with the **interface vlan** command.

Defining a Range Macro

Use the following task to define an interface range macro.

SUMMARY STEPS

1. **enable**
2. configure terminal
3. **define interface-range** *macro_name* {**FastEthernet** *interface-id* [**-** *interface-id*] | {**vlan** *vlan_ID* - *vlan_ID*} | [**, FastEthernet** *interface-id* [**-** *interface-id*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**define interface-range** *macro_name* {**FastEthernet** *interface-id* [**-** *interface-id*] | {**vlan** *vlan_ID* **-** *vlan-ID*} | [**, FastEthernet** *interface-id* [**-** *interface-id*] **Example:** `Router(config)# define interface-range first_three FastEthernet0/1/0 - 2`	• Defines a range of macros.

Verifying Configuration of an Interface Range Macro

Use the **show running-configuration** command to show the defined interface-range macro configuration, as shown below:

```
Router# show running-configuration | include define

define interface-range first_three FastEthernet0/1/0 - 2
```

Configuring Layer 2 Optional Interface Features

- Interface Speed and Duplex Configuration Guidelines, page 15
- Configuring the Interface Speed, page 16
- Configuring the Interface Duplex Mode, page 17
- Verifying Interface Speed and Duplex Mode Configuration, page 17
- Configuring a Description for an Interface, page 18
- Configuring a Fast Ethernet Interface as a Layer 2 Trunk, page 19
- Configuring a Fast Ethernet Interface as Layer 2 Access, page 21

Interface Speed and Duplex Configuration Guidelines

When configuring an interface speed and duplex mode, note these guidelines:

- If both ends of the line support autonegotiation, Cisco highly recommends the default auto negotiation settings.
- If one interface supports auto negotiation and the other end does not, configure duplex and speed on both interfaces; do not use the **auto** setting on the supported side.
- Both ends of the line need to be configured to the same setting; for example, both hard-set or both auto-negotiate. Mismatched settings are not supported.

Caution Changing the interface speed and duplex mode configuration might shut down and reenable the interface during the reconfiguration.

Configuring the Interface Speed

Use the following task to set the interface speed.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface fastethernet** *interface-id*
4. **speed** [**10** | **100** | **auto**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface fastethernet** *interface-id* **Example:** `Router(config)# interface fastethernet 0/1/0`	Selects the interface to be configured.
Step 4	**speed** [**10** | **100** | **auto**] **Example:** `Router(config-if)# speed 100`	Selects the interface to be configured.

Note If you set the interface speed to auto on a 10/100-Mbps Ethernet interface, both speed and duplex are automatically negotiated.

Configuring the Interface Duplex Mode

Follow the steps below to set the duplex mode of a Fast Ethernet interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface fastethernet** *interface-id*
4. **duplex** [**auto** | **full** | **half**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface fastethernet** *interface-id* **Example:** `Router(config)# interface fastethernet 0/1/0`	Selects the interface to be configured.
Step 4	**duplex** [**auto** | **full** | **half**] **Example:** `Router(config-if)# duplex auto`	Sets the duplex mode of the interface.

Note If you set the port speed to auto on a 10/100-Mbps Ethernet interface, both speed and duplex are automatically negotiated. You cannot change the duplex mode of auto negotiation interfaces.

The following example shows how to set the interface duplex mode to auto on Fast Ethernet interface 3:

```
Router(config)# interface fastethernet 0/1/0
Router(config-if)# speed 100
Router(config-if)# duplex auto
Router(config-if)# end
```

Verifying Interface Speed and Duplex Mode Configuration

Use the **show interfaces** command to verify the interface speed and duplex mode configuration for an interface, as shown in the following output example.

```
Router# show interfaces fastethernet 0/1/0
```

```
FastEthernet0/1/0 is up, line protocol is up
 Hardware is Fast Ethernet, address is 000f.f70a.f272 (bia 000f.f70a.f272)
 MTU 1500 bytes, BW 100000 Kbit, DLY 100 usec,
   reliability 255/255, txload 1/255, rxload 1/255
 Encapsulation ARPA, loopback not set
 Keepalive set (10 sec)
 Auto-duplex, Auto-speed
 ARP type: ARPA, ARP Timeout 04:00:00
 Last input 00:00:11, output never, output hang never
 Last clearing of "show interface" counters never
 Queueing strategy: fifo
 Output queue 0/40, (size/max)
 5 minute input rate 0 bits/sec, 0 packets/sec
 5 minute output rate 0 bits/sec, 0 packets/sec
   4 packets input, 1073 bytes, 0 no buffer
   Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
   0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
   0 input packets with dribble condition detected
   6 packets output, 664 bytes, 0 underruns(0/0/0)
   0 output errors, 0 collisions, 3 interface resets
   0 babbles, 0 late collision, 0 deferred
   0 lost carrier, 0 no carrier
   0 output buffer failures, 0 output buffers swapped out
Router#
```

Configuring a Description for an Interface

You can add a description of an interface to help you remember its function. The description appears in the output of the following commands: **show configuration**, **show running-config**, and **show interfaces**.

Use the **description** command to add a description for an interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface fastethernet** *interface-id*
4. **description** *string*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface fastethernet** *interface-id* **Example:** `Router(config)# interface fastethernet 0/1/0`	Selects the interface to be configured.
Step 4	`description` *string* **Example:** `Router(config-if)# description newinterface`	Adds a description for an interface.

Configuring a Fast Ethernet Interface as a Layer 2 Trunk

Use this task to configure a Fast Ethernet interface as a Layer 2 trunk.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface fastethernet** *interface-id*
4. **shutdown**
5. **switchport mode trunk**
6. **switchport trunk native** vlan *vlan-num*
7. **switchport trunk allowed vlan** {**add** | **except** | **none** | **remove**} **vlan1**[**,***vlan*[**,***vlan*[**,**...]]]
8. **no shutdown**
9. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface fastethernet** *interface-id* **Example:** `Router(config)# interface fastethernet 0/1/0`	Selects the interface to be configured.
Step 4	**shutdown** **Example:** `Router(config-if)# shutdown`	(Optional) Shuts down the interface to prevent traffic flow until configuration is complete.
Step 5	**switchport mode trunk** **Example:** `Router(config-if)# switchport mode trunk`	Configures the interface as a Layer 2 trunk. **Note** Encapsulation is always dot1q.
Step 6	**switchport trunk native vlan** *vlan-num* **Example:** `Router(config-if)# switchport trunk native vlan 1`	(Optional) For 802.1Q trunks, specifies the native VLAN.
Step 7	**switchport trunk allowed vlan** {**add** | **except** | **none** | **remove**} *vlan1*[**,***vlan*[**,***vlan*[**,...**]]] **Example:** `Router(config-if)# switchport trunk allowed vlan add vlan1, vlan2, vlan3`	(Optional) Configures the list of VLANs allowed on the trunk. All VLANs are allowed by default. You cannot remove any of the default VLANs from a trunk.
Step 8	**no shutdown** **Example:** `Router(config-if)# no shutdown`	Activates the interface. (Required only if you shut down the interface.)
Step 9	**end** **Example:** `Router(config-if)# end`	Exits configuration mode.

Note Ports do not support Dynamic Trunk Protocol (DTP). Ensure that the neighboring switch is set to a mode that will not send DTP.

Verifying a Fast Ethernet Interface as a Layer 2 Trunk

Use the following **show** commands to verify the configuration of a Fast Ethernet interface as a Layer 2 trunk.

```
router# show running-config interfaces fastEthernet 0/3/1

Building configuration...
Current configuration: 71 bytes
!
interface FastEthernet0/3/1
  switchport mode trunk
  no ip address
end
Router#

Router# show interfaces trunk

Port  Mode  Encapsulation  Status  Native vlan
Fa0/3/1  on     802.1q      trunking     1

Port  Vlans allowed on trunk
Fa0/3/1    1-1005

Port  Vlans allowed and active in management domain
Fa0/3/1    1

Port  Vlans in spanning tree forwarding state and not pruned
Fa0/3/1    1

Router#
```

Configuring a Fast Ethernet Interface as Layer 2 Access

Follow these steps below to configure a Fast Ethernet interface as Layer 2 access.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface fastethernet** *interface-id*
4. **shutdown**
5. **switchport mode access**
6. **switchport access vlan** *vlan-num*
7. **no shutdown**
8. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface fastethernet** *interface-id* **Example:** `Router(config)# interface fastethernet 0/1/0`	Selects the interface to be configured.
Step 4	**shutdown** **Example:** `Router(config-if)# shutdown`	(Optional) Shuts down the interface to prevent traffic flow until configuration is complete.
Step 5	**switchport mode access** **Example:** `Router(config-if)# switchport mode access`	Configures the interface as a Layer 2 access.
Step 6	**switchport access vlan** *vlan-num* **Example:** `Router(config-if)# switchport access vlan 1`	For access ports, specifies the access VLAN.
Step 7	**no shutdown** **Example:** `Router(config-if)# no shutdown`	Activates the interface. • Required only if you shut down the interface.
Step 8	**end** **Example:** `Router(config-if)# end`	Exits configuration mode.

Verifying a Fast Ethernet Interface as Layer 2 Access

Use the **show running-config interface** command to verify the running configuration of the interface, as shown below.

```
Router# show running-config interface fastethernet 0/1/2

Building configuration...
Current configuration: 76 bytes
!
interface FastEthernet0/1/2
```

```
  switchport access vlan 3
  no ip address
end
```

Use the **show interfaces** command to verify the switchport configuration of the interface, as shown below.

```
Router# show interfaces f0/1/0 switchport

Name: Fa0/1/0
Switchport: Enabled
Administrative Mode: static access
Operational Mode: static access
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: native
Negotiation of Trunking: Disabled
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
Trunking VLANs Enabled: ALL
Trunking VLANs Active: 1
Priority for untagged frames: 0
Override vlan tag priority: FALSE
Voice VLAN: none
Appliance trust: none

Router#
```

Configuring 802.1x Authentication

This section describes how to configure 802.1x port-based authentication on an EtherSwitch HWIC:

- Information About the Default 802.1x Configuration, page 23
- Enabling 802.1x Authentication, page 25
- Configuring the Switch-to-RADIUS-Server Communication, page 26
- Enabling Periodic Reauthentication, page 28
- Changing the Quiet Period, page 29
- Changing the Switch-to-Client Retransmission Time, page 30
- Setting the Switch-to-Client Frame-Retransmission Number, page 32
- Enabling Multiple Hosts, page 33
- Resetting the 802.1x Configuration to the Default Values, page 34
- Displaying 802.1x Statistics and Status, page 35

Information About the Default 802.1x Configuration

Table 1 shows the default 802.1x configuration.

Table 1 Default 802.1x Configuration

Feature	Default Setting
Authentication, authorization, and accounting (AAA)	Disabled.
RADIUS server • IP address • UDP authentication port • Key	 • None specified. • 1645. • None specified.
Per-interface 802.1x enable state	Disabled (force-authorized). The port transmits and receives normal traffic without 802.1x-based authentication of the client.
Periodic reauthentication	Disabled.
Number of seconds between reauthentication attempts	3600 seconds.
Quiet period	60 seconds (number of seconds that the switch remains in the quiet state following a failed authentication exchange with the client).
Retransmission time	30 seconds (number of seconds that the switch should wait for a response to an EAP request/identity frame from the client before retransmitting the request).
Maximum retransmission number	2 times (number of times that the switch will send an EAP-request/identity frame before restarting the authentication process).
Multiple host support	Disabled.
Client timeout period	30 seconds (when relaying a request from the authentication server to the client, the amount of time the switch waits for a response before retransmitting the request to the client). This setting is not configurable.
Authentication server timeout period	30 seconds (when relaying a response from the client to the authentication server, the amount of time the switch waits for a reply before retransmitting the response to the server). This setting is not configurable.

802.1x Configuration Guidelines

These are the 802.1x authentication configuration guidelines:

- When the 802.1x protocol is enabled, ports are authenticated before any other Layer 2 feature is enabled.
- The 802.1x protocol is supported on Layer 2 static-access ports, but it is not supported on these port types:
  - Trunk port—If you try to enable 802.1x on a trunk port, an error message appears, and 802.1x is not enabled. If you try to change the mode of an 802.1x-enabled port to trunk, the port mode is not changed.

– Switch Port Analyzer (SPAN) destination port—You can enable 802.1x on a port that is a SPAN destination port; however, 802.1x is disabled until the port is removed as a SPAN destination. You can enable 802.1x on a SPAN source port.

Enabling 802.1x Authentication

To enable 802.1x port-based authentication, you must enable AAA and specify the authentication method list. A method list describes the sequence and authentication methods to be queried to authenticate a user.

The software uses the first method listed to authenticate users; if that method fails to respond, the software selects the next authentication method in the method list. This process continues until there is successful communication with a listed authentication method or until all defined methods are exhausted. If authentication fails at any point in this cycle, the authentication process stops, and no other authentication methods are attempted.

Beginning in privileged EXEC mode, follow these steps to configure 802.1x port-based authentication. This procedure is required.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa authentication** dot1x {**default** | *listname*} *method1* [*method2*...]
4. **interface** *interface-id*
5. **dot1x port-control auto**
6. **end**
7. **show dot1x**
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**aaa authentication** dot1x {**default** | *listname*} *method1* [*method2*...] **Example:** `Router(config)# aaa authentication dot1x default newmethod`	Creates an 802.1x authentication method list. • To create a default list that is used when a named list is *not* specified in the **authentication** command, use the **default** keyword followed by the methods that are to be used in default situations. The default method list is automatically applied to all interfaces. • Enter at least one of these keywords: – **group radius**—Use the list of all RADIUS servers for authentication. – **none**—Use no authentication. The client is automatically authenticated without the switch using the information supplied by the client.
Step 4	**interface** *interface-id* **Example:** `Router(config)# interface 0/1/3`	Enters interface configuration mode and specifies the interface to be enabled for 802.1x authentication.
Step 5	**dot1x port-control auto** **Example:** `Router(config-if)# dot1x port-control auto`	Enables 802.1x on the interface. • For feature interaction information with trunk, dynamic, dynamic-access, EtherChannel, secure, and SPAN ports see the "802.1x Configuration Guidelines" section on page 24.
Step 6	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.
Step 7	**show dot1x** **Example:** `Router# show dot1x`	Verifies your entries.
Step 8	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

To disable AAA, use the **no aaa new-model** global configuration command. To disable 802.1x AAA authentication, use the **no aaa authentication dot1x** {**default** | *list-name*} *method1* [*method2*...] global configuration command. To disable 802.1x, use the **dot1x port-control force-authorized** or the **no dot1x port-control** interface configuration command.

Configuring the Switch-to-RADIUS-Server Communication

RADIUS security servers are identified by their host name or IP address, host name and specific UDP port numbers, or IP address and specific UDP port numbers. The combination of the IP address and UDP port number creates a unique identifier, which enables RADIUS requests to be sent to multiple UDP ports on a server at the same IP address. If two different host entries on the same RADIUS server are

configured for the same service—for example, authentication—the second host entry configured acts as the fail-over backup to the first one. The RADIUS host entries are tried in the order that they were configured.

Follow these steps to configure the RADIUS server parameters on the switch. This procedure is required.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **radius-server host** {*hostname* | *ip-address*} **auth-port** *port-number* **key** *string*
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**radius-server host** {*hostname* | *ip-address*} **auth-port** *port-number* **key** *string* **Example:** `Router# raduis-server host hostseven auth-port 75 key newauthority75`	Configures the RADIUS server parameters on the switch. • For *hostname* | *ip-address,* specify the host name or IP address of the remote RADIUS server. • For **auth-port** *port-number*, specify the UDP destination port for authentication requests. The default is 1645. • For **key** *string*, specify the authentication and encryption key used between the switch and the RADIUS daemon running on the RADIUS server. The key is a text string that must match the encryption key used on the RADIUS server. **Note** Always configure the key as the last item in the **radius-server host** command syntax because leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in the key, do not enclose the key in quotation marks unless the quotation marks are part of the key. This key must match the encryption used on the RADIUS daemon. • If you want to use multiple RADIUS servers, repeat this command.

	Command or Action	Purpose
Step 4	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.
Step 5	**show running-config** **Example:** `Router# show running-config`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

To delete the specified RADIUS server, use the **no radius-server host** {*hostname* | *ip-address*} global configuration command.

You can globally configure the timeout, retransmission, and encryption key values for all RADIUS servers by using the **radius-server host** global configuration command. If you want to configure these options on a per-server basis, use the **radius-server timeout**, **radius-server retransmit**, and the **radius-server key** global configuration commands.

You also need to configure some settings on the RADIUS server. These settings include the IP address of the switch and the key string to be shared by both the server and the switch. For more information, refer to the RADIUS server documentation.

Enabling Periodic Reauthentication

You can enable periodic 802.1x client reauthentication and specify how often it occurs. If you do not specify a time period before enabling reauthentication, the number of seconds between reauthentication attempts is 3600 seconds.

Automatic 802.1x client reauthentication is a global setting and cannot be set for clients connected to individual ports.

Follow these steps to enable periodic reauthentication of the client and to configure the number of seconds between reauthentication attempts.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **dot1x re-authentication**
4. **dot1x timeout re-authperiod** *seconds*
5. **end**
6. **show dot1x**
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**dot1x re-authentication** **Example:** `Router(config)# dot1x re-authentication`	Enables periodic reauthentication of the client. • Periodic reauthentication is disabled by default.
Step 4	**dot1x timeout re-authperiod** *seconds* **Example:** `Router(config)# dot1x timeout re-authperiod 120`	Sets the number of seconds between reauthentication attempts. • The range is 1 to 4294967295; the default is 3600 seconds. • This command affects the behavior of the switch only if periodic reauthentication is enabled
Step 5	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.
Step 6	**show dot1x** **Example:** `Router# show dot1x`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

To disable periodic reauthentication, use the **no dot1x re-authentication** global configuration command. To return to the default number of seconds between reauthentication attempts, use the **no dot1x timeout re-authperiod** global configuration command.

Changing the Quiet Period

When the switch cannot authenticate the client, the switch remains idle for a set period of time, and then tries again. The idle time is determined by the quiet-period value. A failed authentication of the client might occur because the client provided an invalid password. You can provide a faster response time to the user by entering smaller number than the default.

Follow these steps to change the quiet period.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **dot1x timeout quiet-period** *seconds*
4. **end**
5. **show dot1x**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**dot1x timeout quiet-period** *seconds* **Example:** `Router(config)#dot1x timeout quiet-period 120`	Sets the number of seconds that the switch remains in the quiet state following a failed authentication exchange with the client. • The range is 0 to 65535 seconds; the default is 60.
Step 4	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.
Step 5	**show dot1x** **Example:** `Router# show dot1x`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

To return to the default quiet time, use the **no dot1x timeout quiet-period** global configuration command.

Changing the Switch-to-Client Retransmission Time

The client responds to the EAP-request/identity frame from the switch with an EAP-response/identity frame. If the switch does not receive this response, it waits a set period of time (known as the retransmission time), and then retransmits the frame.

Note You should change the default value of this command only to adjust for unusual circumstances such as unreliable links or specific behavioral problems with certain clients and authentication servers.

Follow the steps below to change the amount of time that the switch waits for client notification.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **dot1x timeout tx-period** *seconds*
4. **end**
5. **show dot1x**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**dot1x timeout tx-period** *seconds* **Example:** `Router(config)# dot1x timeout tx-period seconds`	Sets the number of seconds that the switch waits for a response to an EAP-request/identity frame from the client before retransmitting the request. • The range is 1 to 65535 seconds; the default is 30.
Step 4	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.
Step 5	**show dot1x** **Example:** `Router# show dot1x`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

To return to the default retransmission time, use the **no dot1x timeout tx-period** global configuration command.

Setting the Switch-to-Client Frame-Retransmission Number

In addition to changing the switch-to-client retransmission time, you can change the number of times that the switch sends an EAP-request/identity frame (assuming no response is received) to the client before restarting the authentication process.

Note You should change the default value of this command only to adjust for unusual circumstances such as unreliable links or specific behavioral problems with certain clients and authentication servers.

Follow the steps below to set the switch-to-client frame-retransmission number.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **dot1x max-req** *count*
4. **end**
5. **show dot1x**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**dot1x max-req** *count* **Example:** `Router(config)# dot1x max-req 5`	Sets the number of times that the switch sends an EAP-request/identity frame to the client before restarting the authentication process. • The range is 1 to 10; the default is 2.
Step 4	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.

	Command or Action	Purpose
Step 5	**show dot1x** **Example:** `Router# show dot1x`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

To return to the default retransmission number, use the **no dot1x max-req** global configuration command.

Enabling Multiple Hosts

You can attach multiple hosts to a single 802.1x-enabled port. In this mode, only one of the attached hosts must be successfully authorized for all hosts to be granted network access. If the port becomes unauthorized (reauthentication fails, and an EAPOL-logoff message is received), all attached clients are denied access to the network.

Follow these steps below to allow multiple hosts (clients) on an 802.1x-authorized port that has the **dot1x port-control** interface configuration command set to **auto**.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **dot1x multiple-hosts**
5. **end**
6. **show dot1x interface** *interface-id*
7. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**interface** *interface-id* **Example:** `Router# interface 0/1/2`	Enters interface configuration mode.
Step 4	**dot1x multiple-hosts** **Example:** `Router(config-if)# dot1x multiple-hosts`	Allows multiple hosts (clients) on an 802.1x-authorized port. • Make sure that the **dot1x port-control** interface configuration command is set to **auto** for the specified interface.
Step 5	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.
Step 6	**show dot1x** **Example:** `Router# show dot1x`	Verifies your entries.
Step 7	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

To disable multiple hosts on the port, use the **no dot1x multiple-hosts** interface configuration command.

Resetting the 802.1x Configuration to the Default Values

You can reset the 802.1x configuration to the default values with a single command.

Follow these steps to reset the 802.1x configuration to the default values.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **dot1x default**
4. **end**
5. **show dot1x**
6. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**dot1x default** **Example:** `Router(config)# dot1x default`	Resets the configurable 802.1x parameters to the default values.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 5	**show dot1x** **Example:** `Router# show dot1x`	Verifies your entries.
Step 6	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Displaying 802.1x Statistics and Status

To display 802.1x statistics for all interfaces, use the **show dot1x statistics** privileged EXEC command. To display 802.1x statistics for a specific interface, use the **show dot1x statistics interface** *interface-id* privileged EXEC command.

To display the 802.1x administrative and operational status for the switch, use the **show dot1x** privileged EXEC command. To display the 802.1x administrative and operational status for a specific interface, use the **show dot1x interface** *interface-id* privileged EXEC command.

Configuring Spanning Tree

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- Configuring Spanning Tree Port Priority, page 37
- Configuring Spanning Tree Port Cost, page 38
- Configuring the Bridge Priority of a VLAN, page 41
- Configuring Hello Time, page 42

- Configuring the Forward-Delay Time for a VLAN, page 42
- Configuring the Maximum Aging Time for a VLAN, page 43
- Configuring the Root Bridge, page 44

Enabling Spanning Tree

You can enable spanning tree on a per-VLAN basis. The switch maintains a separate instance of spanning tree for each VLAN (except on VLANs on which you disable spanning tree).

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree vlan** *vlan-ID*
4. **end**
5. **show spanning-tree vlan** *vlan-id*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree vlan** *vlan-ID* **Example:** `Router(config)# spanning-tree vlan 200`	Enables spanning tree on a per-VLAN basis
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 5	**show spanning-tree vlan** *vlan-id* **Example:** `Router# show spanning-tree vlan 200`	Verifies spanning tree configuration

Example

Use the **show spanning-tree vlan** to verify spanning tree configuration, as illustrated below:

```
Router# show spanning-tree vlan 200

 VLAN200 is executing the ieee compatible Spanning Tree protocol
  Bridge Identifier has priority 32768, address 0050.3e8d.6401
  Configured hello time 2, max age 20, forward delay 15
  Current root has priority 16384, address 0060.704c.7000
  Root port is 264 (FastEthernet0/1/8), cost of root path is 38
  Topology change flag not set, detected flag not set
  Number of topology changes 0 last change occurred 01:53:48 ago
  Times:  hold 1, topology change 24, notification 2
          hello 2, max age 14, forward delay 10
  Timers: hello 0, topology change 0, notification 0


 Port 264 (FastEthernet0/1/8) of VLAN200 is forwarding
    Port path cost 19, Port priority 128, Port Identifier 129.9.
    Designated root has priority 16384, address 0060.704c.7000
    Designated bridge has priority 32768, address 00e0.4fac.b000
    Designated port id is 128.2, designated path cost 19
    Timers: message age 3, forward delay 0, hold 0
    Number of transitions to forwarding state: 1
    BPDU: sent 3, received 3417

Router#
```

Configuring Spanning Tree Port Priority

Follow the steps below to configure the spanning tree port priority of an interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet**} *interface-id*
4. **spanning-tree port-priority** *port-priority*
5. **spanning-tree vlan** *vlan-ID* **port-priority** *port-priority*
6. **end**
7. **show spanning-tree interface**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**interface** {**ethernet** | **fastethernet**} *interface-id* **Example:** `Router(config)# interface fastethernet 0/1/6`	Selects an interface to configure.
Step 4	**spanning-tree port-priority** *port-priority* **Example:** `Router(config-if)# spanning-tree port-priority 8`	Configures the port priority for an interface. • The of port-priority *value* can be from 4 to 252 in increments of 4. • Use the **no** form of this command to restore the defaults.
Step 5	**spanning-tree vlan** *vlan-ID* **port-priority** *port-priority* **Example:** `Router (config-if)# spanning-tree vlan vlan1 port-priority 12`	Configures the priority for a VLAN.
Step 6	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 7	**show spanning-tree interface fastethernet** *interface-id* **Example:** `Router# show spanning-tree interface fastethernet 0/1/6`	(Optional) Saves your entries in the configuration file.

Example

Use the **show spanning-tree interface** to verify spanning-tree interface and the spanning-tree port priority configuration, as illustrated below:

```
Router# show spanning-tree interface fastethernet 0/1/6

 Port 264 (FastEthernet0/1/6) of VLAN200 is forwarding
   Port path cost 19, Port priority 100, Port Identifier 129.8.
   Designated root has priority 32768, address 0010.0d40.34c7
   Designated bridge has priority 32768, address 0010.0d40.34c7
   Designated port id is 128.1, designated path cost 0
   Timers: message age 2, forward delay 0, hold 0
   Number of transitions to forwarding state: 1
   BPDU: sent 0, received 13513
Router#
```

Configuring Spanning Tree Port Cost

Spanning tree port costs are explained in the following section.

Calculating Port Cost

Port cost value calculations are based on the bandwidth of the port. There are two classes of values. Short (16-bit) values are specified by the IEEE 802.1D specification and range in value from 1 to 65535. Long (32-bit) values are specified by the IEEE 802.1t specification and range in value from 1 to 200,000,000.

Assigning Short Port Cost Values

You can manually assign port costs in the range of 1 to 65535. Default cost values are as follows.

Port Speed	Default Cost Value
10 Mbps	100
100 Mbps	19

Assigning Long Port Cost Values

You can manually assign port costs in the range of 1 to 200,000,000. Recommended cost values are as follows.

Port Speed	Recommended Value	Recommended Range
10 Mbps	2,000,000	200,000 to 20,000,000
100 Mbps	200,000	20,000 to 2,000,000

Follow the steps below to configure the spanning tree port cost of an interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet**} *interface-id*
4. **spanning-tree cost** *port-cost*
5. **spanning-tree vlan** *vlan-ID* **cost** *port-cost*
6. **end**
7. **show spanning-tree interface**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** {**ethernet** | **fastethernet**} *interface-id* **Example:** `Router(config)# interface fastethernet 0/1/6`	Selects an interface to configure.
Step 4	**spanning-tree cost** *port-cost* **Example:** `Router(config-if)# spanning-tree cost 2000`	Configures the port cost for an interface. • The value of port_cost can be from 1 to 200,000,000 (1 to 65,535 in Cisco IOS Releases 12.1(2)E and earlier). • Use the **no** form of this command to restore the defaults.
Step 5	**spanning-tree vlan** *vlan-ID* **cost** *port-cost* **Example:** `Router(config-if)# spanning-tree vlan 200 cost 2000`	Configures the VLAN port cost for an interface. • The value port-cost can be from 1 to 65,535. • Use the **no** form of this command to restore the defaults.
Step 6	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 7	**show spanning-tree interface fastethernet** *interface-id* **Example:** `Router# show spanning-tree interface fastethernet 0/1/6`	(Optional) Saves your entries in the configuration file.

Example

Use the **show spanning-tree vlan** to verify the spanning-tree port cost configuration.

```
Router# show spanning-tree vlan 200

Port 264 (FastEthernet0/1/8) of VLAN200 is forwarding
Port path cost 17, Port priority 64, Port Identifier 129.8.
   Designated root has priority 32768, address 0010.0d40.34c7
   Designated bridge has priority 32768, address 0010.0d40.34c7
   Designated port id is 128.1, designated path cost 0
   Timers: message age 2, forward delay 0, hold 0
```

```
   Number of transitions to forwarding state: 1
   BPDU: sent 0, received 13513

Router#
```

Configuring the Bridge Priority of a VLAN

Use the following task to configure the spanning tree bridge priority of a VLAN.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree vlan** *vlan-ID* **priority** *bridge-priority*
4. **show spanning-tree vlan bridge** [**brief**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree vlan** *vlan-ID* **priority** *bridge-priority* **Example:** `Router(config)# spanning-tree vlan 200 priority 2`	Configures the bridge priority of a VLAN. The *bridge_priority* value can be from 1 to 65535. • Use the **no** form of this command to restore the defaults. **Caution** Exercise care when using this command. For most situations **spanning-tree vlan vlan-ID root primary** and the **spanning-tree vlan vlan-ID root secondary** are the preferred commands to modify the bridge priority.
Step 4	**show spanning-tree vlan bridge** **Example:** `Router(config-if)# spanning-tree cost 200`	Verifies the bridge priority.

Example

Use the **show spanning-tree vlan bridge** command to verify the bridge priority, as shown below.

```
Router# show spanning-tree vlan 200 bridge brief

                                     Hello Max Fwd
Vlan                  Bridge ID      Time  Age Delay  Protocol
---------------- -------------------- ---- ---- -----  --------
VLAN200          33792 0050.3e8d.64c8    2   20    15  ieee
Router#
```

Configuring Hello Time

Use the following tasks to configure the hello interval for the spanning tree.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree vlan** *vlan-ID* **hello-time** *hello-time*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree vlan** *vlan-ID* **hello-time** *hello-time* **Example:** `Router(config)# spanning-tree vlan 200 hello-time 5`	Configures the hello time of a VLAN. • The **hello_time** value can be from 1 to 10 seconds. • Use the **no** form of this command to restore the defaults

Configuring the Forward-Delay Time for a VLAN

Use the following task to configure the forward delay for the spanning tree

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree vlan** *vlan-ID* **forward-time** *forward-time*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree vlan** *vlan-ID* **forward-time** *forward-time* **Example:** `Router(config)# spanning-tree vlan 20 forward-time 5`	Configures the forward time of a VLAN. • The value of *forward-time* can be from 4 to 30 seconds. • Use the **no** form of this command to restore the defaults.

Configuring the Maximum Aging Time for a VLAN

Follow the steps below to configure the maximum age interval for the spanning tree.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree vlan** *vlan-ID* **max-age** *max-age*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree vlan** *vlan-ID* **max-age** *max-age* **Example:** `Router(config)# spanning-tree vlan 200 max-age 30`	Configures the maximum aging time of a VLAN. • The value of *max_age* can be from 6 to 40 seconds. • Use the **no** form of this command to restore the defaults.

Configuring the Root Bridge

The EtherSwitch HWIC maintains a separate instance of spanning tree for each active VLAN configured on the switch. A bridge ID, consisting of the bridge priority and the bridge MAC address, is associated with each instance. For each VLAN, the switch with the lowest bridge ID will become the root bridge for that VLAN.

To configure a VLAN instance to become the root bridge, the bridge priority can be modified from the default value (32768) to a significantly lower value so that the bridge becomes the root bridge for the specified VLAN. Use the **spanning-tree vlan root** command to alter the bridge priority.

The switch checks the bridge priority of the current root bridges for each VLAN. The bridge priority for the specified VLANs is set to 8192 if this value will cause the switch to become the root for the specified VLANs.

If any root switch for the specified VLANs has a bridge priority lower than 8192, the switch sets the bridge priority for the specified VLANs to 1 less than the lowest bridge priority.

For example, if all switches in the network have the bridge priority for VLAN 100 set to the default value of 32768, entering the spanning-tree vlan 100 root primary command on a switch will set the bridge priority for VLAN 100 to 8192, causing the switch to become the root bridge for VLAN 100.

Note The root switch for each instance of spanning tree should be a backbone or distribution switch. Do not configure an access switch as the spanning tree primary root.

Use the **diameter** keyword to specify the Layer 2 network diameter (that is, the maximum number of bridge hops between any two end stations in the Layer 2 network). When you specify the network diameter, the switch automatically picks an optimal hello time, forward delay time, and maximum age time for a network of that diameter, which can significantly reduce the spanning tree convergence time. You can use the **hello** keyword to override the automatically calculated hello time.

Note We recommend that you avoid configuring the hello time, forward delay time, and maximum age time manually after configuring the switch as the root bridge.

Follow these steps to configure the switch as the root.:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **spanning-tree vlan** *vlaN-ID* **root primary** [**diameter** *hops* [**hello-time** *seconds*]]
4. **end**
5. **no spanning-tree vlan** *vlan-ID*
6. **show spanning-tree vlan** *vlan-ID*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**spanning-tree vlan** *vlan-ID* **root primary** [**diameter** *hops* [**hello-time** *seconds*]] **Example:** `Router(config)# spanning-tree vlan 200 root primary`	Configures a switch as the root switch. • Use the **no** form of this command to restore the defaults.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 5	**no spanning-tree vlan** *vlan-ID* **Example:** `Router(config)# spanning-tree vlan 200 root primary`	Disables spanning tree on a per-VLAN basis.
Step 6	**show spanning-tree vlan** *vlan-ID* **Example:** `Router(config)# show spanning-tree vlan 200`	Verifies spanning tree on a per-VLAN basis.

Example

Use the **show spanning-tree vlan** command to verify the that the spanning tree is disabled, as illustrated below:

```
Router# show spanning-tree vlan 200

<output truncated>
Spanning tree instance for VLAN 200 does not exist.
Router#
```

Configuring MAC Table Manipulation

Port security is implemented by providing the user with the option to make a port secure by allowing only well-known MAC addresses to send in data traffic. Up to 200 secure MAC addresses per HWIC are supported.

- Enabling Known MAC Address Traffic, page 46
- Creating a Static Entry in the MAC Address Table, page 47
- Configuring and Verifying the Aging Timer, page 49

Enabling Known MAC Address Traffic

Follow these steps to enable the MAC address secure option.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mac-address-table secure** *mac-address* **fastethernet** *interface-id* [**vlan** *vlan-id*]
4. **end**
5. **show mac-address-table secure**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mac-address-table secure** *mac-address* **fastethernet** *interface-id* [**vlan** *vlan-id*]] **Example:** `Router(config)# mac-address-table secure 0000.0002.0001 fastethernet 0/1/1 vlan 2`	Secures the MAC address traffic on the port.

	Command or Action	Purpose
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 5	**show mac-address-table secure** **Example:** `Router# show mac-address-table secure`	Verifies the configuration.

Example

Use the **show mac-address-table secure** to verify the configuration, as illustrated below:

```
Router# show mac-address-table secure

Secure Address Table:
Destination Address  Address Type  VLAN  Destination Port
-------------------  ------------  ----  --------------------
0000.0002.0001          Secure        2     FastEthernet0/1/1
```

Creating a Static Entry in the MAC Address Table

Follow these steps to create a static entry in the MAC address table.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mac-address-table static** *mac-address* **fastethernet** *interface-id* [**vlan** *vlan-id*]
4. **end**
5. **show mac-address-table**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	`Router(config)# mac-address-table static` *mac-address* **fastethernet** *interface-id* [**vlan** *vlan-id*] **Example:** `Router(config)# mac-address-table static 00ff.ff0d.2dc0 fastethernet 0/1/1`	Creates a static entry in the MAC address table. When the *vlan-id* is not specified, VLAN 1 is taken by default.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 5	**show mac-address-table** **Example:** `Router# show mac-address-table`	Verifies the MAC address table.

Example

Use the **show mac** command to verify the MAC address table, as illustrated below:

```
Router# show mac-address-table

Destination Address  Address Type  VLAN  Destination Port
-------------------  ------------  ----  --------------------
00ff.ff0d.2dc0          Self         1     Vlan1
0007.ebc7.ff84          Static       1     FastEthernet0/3/5
0007.ebc8.018b          Static       1     FastEthernet0/3/6
000b.bf94.0006          Static       1     FastEthernet0/3/3
000b.bf94.0038          Static       1     FastEthernet0/3/0
000b.bf94.0039          Static       1     FastEthernet0/3/1
000b.bf94.0008          Static     314     FastEthernet0/3/2
000b.bf94.0038          Static     314     FastEthernet0/3/0
000b.bf94.0008          Static     331     FastEthernet0/3/2
000b.bf94.0038          Static     331     FastEthernet0/3/0
000b.bf94.0008          Static     348     FastEthernet0/3/2
000b.bf94.0038          Static     348     FastEthernet0/3/0
```

Configuring and Verifying the Aging Timer

The aging timer may be configured from 16 seconds to 4080 seconds, in 16-second increments.

Follow these steps to configure the aging timer.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mac-address-table aging-time** *time*
4. **end**
5. **show mac-address-table aging-time**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mac-address-table aging-time** *time* **Example:** `Router(config)# mac-address-table aging-time 4080`	Configures the MAC address aging timer age in seconds. • The range is 0 to 10000 seconds.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 5	**show mac-address-table aging-time** **Example:** `Router# show mac-address-table aging-time`	Verifies the MAC address table.

Example

Use the **show mac-address-table aging-time** command to verify the MAC address table aging timer, as illustrated below:

```
Router # show mac-address-table aging-time
Mac address aging time 320
```

Configuring Cisco Discovery Protocol

- Enabling Cisco Discovery Protocol, page 50
- Enabling CDP on an Interface, page 51
- Monitoring and Maintaining CDP, page 52

Enabling Cisco Discovery Protocol

To enable Cisco Discovery Protocol (CDP) globally, use the following commands.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **cdp run**
4. **end**
5. **show cdp**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**cdp run** **Example:** `Router(config)# cdp run`	Enables CDP globally.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 5	**show cdp** **Example:** `Router# show cdp`	Verifies the CDP configuration.

Example

Use the **show cdp** command to verify the CDP configuration:

```
Router# show cdp

Global CDP information:
        Sending CDP packets every 120 seconds
        Sending a holdtime value of 180 seconds
        Sending CDPv2 advertisements is enabled
Router#
```

Enabling CDP on an Interface

Use the steps below to enable CDP on an interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** {**ethernet** | **fastethernet**}
4. **cdp enable**
5. **end**
6. **show cdp interface** *interface-id*
7. show cdp neighbors

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** {**ethernet** | **fastethernet**} *interface-id* **Example:** `Router(config)# interface fastethernet 0/1/1`	Selects an interface to configure.
Step 4	**cdp enable** **Example:** `Router(config)# cdp enable`	Enables CDP globally.

	Command or Action	Purpose
Step 5	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 6	**show cdp interface** *interface-id* **Example:** `Router# show cdp interface`	Verifies the CDP configuration on the interface.
Step 7	**show cdp neighbors** **Example:** `Router# show cdp neighbors`	Verifies the information about the neighboring equipment.

Example

Use the **show cdp** command to verify the CDP configuration for an interface.

```
Router# show cdp interface fastethernet 0/1/1

FastEthernet0/1/1 is up, line protocol is up
  Encapsulation ARPA
  Sending CDP packets every 120 seconds
  Holdtime is 180 seconds
Router#

Router# show cdp neighbors

Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater
Device ID        Local Intrfce     Holdtme    Capability  Platform  Port ID
tftp-switch      Fas 0/0             125       R S I     2811      Fas 0/3/6
hwic-3745-2      Fas 0/1/0           149       R S I     3745      Fas 0/1
Router#
```

Monitoring and Maintaining CDP

Use the following commands to monitor and maintain CDP on your device.

SUMMARY STEPS

1. **enable**
2. **clear cdp counters**
3. **clear cdp table**
4. **show cdp**
5. **show cdp entry** *entry-name* [**protocol | version**]
6. **show cdp interface** *interface-id*
7. **show cdp neighbors** *interface-id* [**detail**]
8. **show cdp traffic**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**clear cdp counters** **Example:** `Router# clear cdp counters`	(Optional) Resets the traffic counters to zero.
Step 3	**clear cdp table** **Example:** `Router# clear cdp table`	(Optional) Deletes the CDP table of information about neighbors.
Step 4	**show cdp** **Example:** `Router# show cdp`	(Optional) Verifies global information such as frequency of transmissions and the holdtime for packets being transmitted.
Step 5	**show cdp entry** *entry_name* [**protocol** | **version**] **Example:** `Router# show cdp entry newentry`	(Optional) Verifies information about a specific neighbor. • The display can be limited to protocol or version information.
Step 6	**show cdp interface** *interface-id* **Example:** `Router# show cdp interface 0/1/1`	(Optional) Verifies information about interfaces on which CDP is enabled.
Step 7	**show cdp neighbors** *interface-id* [**detail**] **Example:** `Router# show cdp neighbors 0/1/1`	(Optional) Verifies information about neighbors. • The display can be limited to neighbors on a specific interface and can be expanded to provide more detailed information.
Step 8	**show cdp traffic** **Example:** `Router# show cdp traffic`	(Optional) Verifies CDP counters, including the number of packets sent and received and checksum errors.

Configuring the Switched Port Analyzer (SPAN)

This section describes how to configure a switched port analyzer (SPAN) session for an EtherSwitch HWIC.

- Configuring the SPAN Sources, page 54
- Configuring SPAN Destinations, page 54
- Configuring Power Management on the Interface, page 56

Note An EtherSwitch HWIC supports only one SPAN session. Either Tx or both Tx and Rx monitoring is supported.

Configuring the SPAN Sources

Use the following task to configure the source for a SPAN session.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **monitor session 1** {**source** {**interface** *interface-id*} | {**vlan** *vlan-ID*}} [**,** | **-** | **rx** | **tx** | **both**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**monitor session 1** {**source** {**interface** *interface-id*}	{**vlan** *vlan-ID*}} [**,**	**-**	**rx**	**tx**	**both**] **Example:** `Router(config)# monitor session 1 source interface fastethernet 0/3/1`	Specifies the SPAN session (number 1), the source interfaces or VLANs, and the traffic direction to be monitored. • The example shows how to configure the SPAN session to monitor bidirectional traffic from source interface Fast Ethernet 0/3/1.

Configuring SPAN Destinations

To configure the destination for a SPAN session, use the following commands.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **monitor session** *session-id* {**destination** {**interface** *type interface-id*} [**,** | **-**] | {**vlan** *vlan-ID*}}
4. **show monitor session**
5. **no monitor session** *session-id*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**monitor session** *session-id* {**destination** {**interface** *interface-id*} | {**vlan** *vlan-ID*}} [, | - | **rx** | **tx** | **both**] **Example:** `Router(config)# monitor session 1 source interface fastethernet 0/3/1`	Specifies the SPAN session (number 1), the source interfaces or VLANs, and the traffic direction to be monitored. • The example shows how to configure the SPAN session to monitor bidirectional traffic from source interface Fast Ethernet 0/3/1.
Step 4	**show monitor session** *session-id* **Example:** `Router(config)# show monitor session 1`	Verifies the sources and destinations configured for the SPAN session.
Step 5	**no monitor session** *session-id* **Example:** `Router(config)# no monitor session 1`	Clears existing SPAN configuration.

Example

Use the **show monitor session** command to verify the sources and destinations configured for the SPAN session.

```
Router# show monitor session 1

Session 1
---------
Source Ports:
 RX Only: None
 TX Only: None
 Both: Fa0/1/0
Source VLANs:
 RX Only: None
 TX Only: None
 Both: None
Destination Ports: Fa0/1/1
Filter VLANs: None
```

Configuring Power Management on the Interface

The HWICs can supply inline power to a Cisco 7960 IP phone, if necessary. The Cisco 7960 IP phone can also be connected to an AC power source and supply its own power to the voice circuit. When the Cisco 7960 IP phone is supplying its own power, an HWICs can forward IP voice traffic to and from the phone.

A detection mechanism on the HWIC determines whether it is connected to a Cisco 7960 IP phone. If the switch senses that there is *no* power on the circuit, the switch supplies the power. If there is power on the circuit, the switch does not supply it.

You can configure the switch never to supply power to the Cisco 7960 IP phone and to disable the detection mechanism.

Follow these steps to manage the powering of the Cisco IP phones.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface fastethernet** *interface-id*
4. **power inline** {**auto** | **never**}
5. **end**
6. **show power inline**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface fastethernet** *interface-id* **Example:** `Router(config)# interface fastethernet 0/3/1`	Selects a particular Fast Ethernet interface for configuration.
Step 4	**power inline** {**auto**	**never**} **Example:** Router(config-if)# power inline auto	Configures the port to supply inline power automatically to a Cisco IP phone. • Use **never** to permanently disable inline power on the port.

	Command	Purpose
Step 5	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.
Step 6	**show power inline** **Example:** Router# show power inline	Displays power configuration on the ports.

Example

Use the **show power inline** command to verify the power configuration on the ports, as illustrated below.

```
Router# show power inline

PowerSupply   SlotNum.   Maximum   Allocated    Status
-----------   --------   -------   ---------    ------
 INT-PS          0       120.000    101.500     PS GOOD

Interface     Config     Phone     Powered      PowerAllocated
---------     ------     -----     -------      --------------
Fa0/1/0         auto       Cisco     On           6.300 Watts
Fa0/1/1         auto       Cisco     On           6.300 Watts
Fa0/1/2         auto       Cisco     On           6.300 Watts
Fa0/1/3         auto       Cisco     On           6.300 Watts
Fa0/1/4         auto       Cisco     On           6.300 Watts
Fa0/1/5         auto       Cisco     On           6.300 Watts
Fa0/1/6         auto       Cisco     On           6.300 Watts
Fa0/1/7         auto       Cisco     On           6.300 Watts
Fa0/3/0         auto       Cisco     On           6.300 Watts
Fa0/3/1         auto       Cisco     On           6.300 Watts
Fa0/3/2         auto       Cisco     On           6.300 Watts
Fa0/3/3         auto       Cisco     On           6.300 Watts
Fa0/3/4         auto       Cisco     On           6.300 Watts
Fa0/3/5         auto       Cisco     On           6.300 Watts
Fa0/3/6         auto       IEEE-2    On           7.000 Watts
Fa0/3/7         auto       Cisco     On           6.300 Watts
```

Configuring IP Multicast Layer 3 Switching

These sections describe how to configure IP multicast Layer 3 switching:

- Enabling IP Multicast Routing Globally, page 57
- Enabling IP Protocol-Independent Multicast (PIM) on Layer 3 Interfaces, page 59
- Verifying IP Multicast Layer 3 Hardware Switching Summary, page 60
- Verifying the IP Multicast Routing Table, page 61

Enabling IP Multicast Routing Globally

You must enable IP multicast routing globally before you can enable IP multicast Layer 3 switching on Layer 3 interfaces.

For complete information and procedures, refer to these publications:

- *Cisco IOS IP Configuration Guide*, Release 12.2, at this URL:
  http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fipr_c/
- *Cisco IOS IP Command Reference, Volume 1 of 3: Addressing and Services*, Release 12.2, at this URL:
  http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fipras_r/index.htm
- *Cisco IOS IP Command Reference, Volume 2 of 3: Routing Protocols*, Release 12.2, at this URL:
  http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fiprrp_r/index.htm
- *Cisco IOS IP Command Reference, Volume 3 of 3: Multicast*, Release 12.2, at this URL:
  http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fiprmc_r/index.htm

Use the following commands to enable IP multicast routing globally.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip multicast-routing**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip multicast-routing** **Example:** `Router(config)# ip multicast-routing`	Enables IP multicast routing globally.

Enabling IP Protocol-Independent Multicast (PIM) on Layer 3 Interfaces

You must enable protocol-independent multicast (PIM) on the Layer 3 interfaces before enabling IP multicast Layer 3 switching functions on those interfaces.

Beginning in global configuration mode, follow these steps to enable IP PIM on a Layer 3 interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface vlan** *vlan-id*
4. **ip pim** {**dense-mode** | **sparse-mode** | **sparse-dense-mode**}

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface vlan** *vlan-id* `Router(config)# interface vlan 1`	Selects the interface to be configured.
Step 4	**ip pim** {**dense-mode** | **sparse-mode** | **sparse-dense-mode**} **Example:** `Router(config-if)# ip pim sparse-dense mode`	Enables IP PIM on a Layer 3 interface.

Examples

The following example shows how to enable PIM on an interface using the default mode (sparse-dense-mode):

```
Router(config-if)# ip pim sparse-dense mode
Router(config-if)#
```

The following example shows how to enable PIM sparse mode on an interface:

```
Router(config-if)# ip pim sparse-mode
Router(config-if)#
```

Verifying IP Multicast Layer 3 Hardware Switching Summary

Note The **show interface statistics** command does not verify hardware-switched packets, only packets switched by software.

The **show ip pim interface count** command verifies the IP multicast Layer 3 switching enable state on IP PIM interfaces and verifies the number of packets received and sent on the interface.

Use the following **show** commands to verify IP multicast Layer 3 switching information for an IP PIM Layer 3 interface.

Step 1 `Router# show ip pim interface count`

```
State:* - Fast Switched, D - Distributed Fast Switched
      H - Hardware Switching Enabled
Address          Interface            FS  Mpackets In/Out
10.0.0.1         VLAN1                *   151/0
Router#
```

Step 2 `Router# show ip mroute count`

```
IP Multicast Statistics
5 routes using 2728 bytes of memory
4 groups, 0.25 average sources per group
Forwarding Counts:Pkt Count/Pkts per second/Avg Pkt Size/Kilobits per second
Other counts:Total/RPF failed/Other drops(OIF-null, rate-limit etc)

Group:209.165.200.225 Source count:1, Packets forwarded: 0, Packets received: 66
  Source:10.0.0.2/32, Forwarding:0/0/0/0, Other:66/0/66
Group:209.165.200.226, Source count:0, Packets forwarded: 0, Packets received: 0
Group:209.165.200.227, Source count:0, Packets forwarded: 0, Packets received: 0
Group:209.165.200.228, Source count:0, Packets forwarded: 0, Packets received: 0
Router#
```

Note A negative counter means that the outgoing interface list of the corresponding entry is NULL, and this indicates that this flow is still active.

Step 3 `Router# show ip interface vlan 1`

```
Vlan1 is up, line protocol is up
  Internet address is 10.0.0.1/24
  Broadcast address is 209.165.201.1
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Multicast reserved groups joined:209.165.201.2 209.165.201.3 209.165.201.4 209.165.201.5
  Outgoing access list is not set
  Inbound  access list is not set
  Proxy ARP is enabled
  Local Proxy ARP is disabled
  Security level is default
  Split horizon is enabled
  ICMP redirects are always sent
  ICMP unreachables are always sent
  ICMP mask replies are never sent
  IP fast switching is enabled
```

```
  IP fast switching on the same interface is disabled
  IP Flow switching is disabled
  IP CEF switching is enabled
  IP CEF Fast switching turbo vector
  IP multicast fast switching is enabled
  IP multicast distributed fast switching is disabled
  IP route-cache flags are Fast, CEF
  Router Discovery is disabled
  IP output packet accounting is disabled
  IP access violation accounting is disabled
  TCP/IP header compression is disabled
  RTP/IP header compression is disabled
  Policy routing is disabled
  Network address translation is disabled
  WCCP Redirect outbound is disabled
  WCCP Redirect inbound is disabled
  WCCP Redirect exclude is disabled
  BGP Policy Mapping is disabled
Router#
```

Verifying the IP Multicast Routing Table

Use the **show ip mroute** command to verify the IP multicast routing table:

```
Router# show ip mroute 224.10.103.10

IP Multicast Routing Table
Flags:D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
       U - URD, I - Received Source Specific Host Report, Z - Multicast Tunnel,
       Y - Joined MDT-data group, y - Sending to MDT-data group
Outgoing interface flags:H - Hardware switched, A - Assert winner
Timers:Uptime/Expires
Interface state:Interface, Next-Hop or VCD, State/Mode

(*, 209.165.201.2), 00:09:21/00:02:56, RP 0.0.0.0, flags:DC
  Incoming interface:Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Vlan1, Forward/Sparse-Dense, 00:09:21/00:00:00, H

Router#
```

Note The RPF-MFD flag indicates that the flow is completely hardware switched. The H flag indicates that the flow is hardware-switched on the outgoing interface.

Configuring IGMP Snooping

This section describes how to configure IGMP snooping on your router and consists of the following configuration information and procedures:

- Enabling or Disabling IGMP Snooping, page 62
- Enabling IGMP Immediate-Leave Processing, page 64
- Statically Configuring an Interface to Join a Group, page 65
- Configuring a Multicast Router Port, page 67

Enabling or Disabling IGMP Snooping

By default, IGMP snooping is globally enabled on the EtherSwitch HWIC. When globally enabled or disabled, it is also enabled or disabled in all existing VLAN interfaces. By default, IGMP snooping is enabled on all VLANs, but it can be enabled and disabled on a per-VLAN basis.

Global IGMP snooping overrides the per-VLAN IGMP snooping capability. If global snooping is disabled, you cannot enable VLAN snooping. If global snooping is enabled, you can enable or disable snooping on a VLAN basis.

Follow the steps below to globally enable IGMP snooping on the EtherSwitch HWIC.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip igmp snooping**
4. **end**
5. **show ip igmp snooping**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip igmp snooping** **Example:** `Router(config)# ip igmp snooping`	Globally enables IGMP snooping in all existing VLAN interfaces.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.

	Command	Purpose
Step 5	**show ip igmp snooping** **Example:** `Router# show ip igmp snooping`	Displays snooping configuration.
Step 6	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your configuration to the startup configuration.

To globally disable IGMP snooping on all VLAN interfaces, use the **no ip igmp snooping** global command.

Use the following steps to enable IGMP snooping on a VLAN interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip igmp snooping vlan** *vlan-id*
4. **end**
5. **show ip igmp snooping**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip igmp snooping vlan** *vlan-id* **Example:** `Router(config)# ip igmp snooping vlan 1`	Enables IGMP snooping on the VLAN interface.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.

	Command	Purpose
Step 5	**show ip igmp snooping** [**vlan** *vlan-id*] **Example:** `Router# show ip igmp snooping vlan 1`	Displays snooping configuration. • (Optional) *vlan-id* is the number of the VLAN.
Step 6	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your configuration to the startup configuration.

To disable IGMP snooping on a VLAN interface, use the **no ip igmp snooping vlan** *vlan-id* global configuration command for the specified VLAN number (for example, vlan1).

Enabling IGMP Immediate-Leave Processing

When you enable IGMP Immediate-Leave processing, the EtherSwitch HWIC immediately removes a port from the IP multicast group when it detects an IGMP version 2 Leave message on that port. Immediate-Leave processing allows the switch to remove an interface that sends a Leave message from the forwarding table without first sending out group-specific queries to the interface. You should use the Immediate-Leave feature only when there is only a single receiver present on every port in the VLAN.

Use the following steps to enable IGMP Immediate-Leave processing.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip igmp snooping vlan** *vlan-id* **immediate-leave**
4. **end**
5. **show ip igmp snooping**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command	Purpose
Step 3	**ip igmp snooping vlan** *vlan-id* **immediate-leave** **Example:** `Router(config)# ip igmp snooping vlan 1 immediate-leave`	Enables IGMP Immediate-Leave processing on the VLAN interface.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 5	**show ip igmp snooping** **Example:** `Router# show ip igmp snooping`	Displays snooping configuration.
Step 6	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your configuration to the startup configuration.

To disable Immediate-Leave processing, follow Steps 1 and 2 to enter interface configuration mode, and use the **no ip igmp snooping vlan** *vlan-id* **immediate-leave** global configuration command.

Statically Configuring an Interface to Join a Group

Ports normally join multicast groups through the IGMP report message, but you can also statically configure a host on an interface.

Follow the steps below to add a port as a member of a multicast group.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip igmp snooping vlan** *vlan-id* **static** *mac-address* **interface** *interface-id*
4. **end**
5. **show mac-address-table multicast** [**vlan** *vlan-id*] [**user** | **igmp-snooping**] [**count**]
6. **show igmp snooping**
7. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip igmp snooping vlan** *vlan-id* **static** *mac-address* **interface** *interface-id* **Example:** `Router(config)# ip igmp snooping vlan 1 static 0100.5e05.0505 interface Fa0/1/1`	Enables IGMP snooping on the VLAN interface.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 5	**show mac-address-table multicast** [**vlan** *vlan-id*] [**user** | **igmp-snooping**] [**count**] **Example:** `Router# show mac-address-table multicast vlan 1 igmp-snooping`	Displays MAC address table entries for a VLAN. • *vlan-id* is the multicast group VLAN ID. • **user** displays only the user-configured multicast entries. • **igmp-snooping** displays entries learned via IGMP snooping. • **count** displays only the total number of entries for the selected criteria, not the actual entries.
Step 6	**show ip igmp snooping** **Example:** `Router# show ip igmp snooping`	Displays snooping configuration.
Step 7	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your configuration to the startup configuration.

Configuring a Multicast Router Port

Follow the steps below to enable a static connection to a multicast router.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip igmp snooping vlan** *vlan-id* **mrouter** {**interface** *interface-id* | **learn pim-dvmrp**}
4. **end**
5. **show ip igmp snooping**
6. **show ip igmp snooping mrouter** [**vlan** *vlan-id*]
7. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**ip igmp snooping vlan** *vlan-id* **mrouter** {**interface** *interface-id* | **learn pim-dvmrp**} **Example:** `Router(config)# ip igmp snooping vlan1 interface Fa0/1/1 learn pim-dvmrp`	Enables IGMP snooping on the VLAN interface and enables route discovery.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 5	**show ip igmp snooping** **Example:** `Router# show ip igmp snooping`	Displays snooping configuration.

	Command	Purpose
Step 6	**show ip igmp snooping mrouter** [**vlan** *vlan-id*] **Example:** `Router# show ip igmp snooping mrouter vlan vlan1`	Displays Mroute discovery information.
Step 7	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your configuration to the startup configuration.

Configuring Per-Port Storm Control

You can use these techniques to block the forwarding of unnecessary flooded traffic. This section describes how to configure per-port storm control and characteristics on your router and consists of the following configuration procedures:

- Enabling Per-Port Storm Control, page 68
- Disabling Per-Port Storm Control, page 69

By default, unicast, broadcast, and multicast suppression is disabled.

Enabling Per-Port Storm Control

Use these steps to enable per-port storm control.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **storm-control** {**broadcast** | **multicast** | **unicast**} **level** *level-high* [*level-low*]
5. **storm-control action shutdown**
6. **end**
7. **show storm-control** [**interface**] [**broadcast** | **multicast** | **unicast** | **history**]

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Router(config)# interface 0/3/1`	Enters interface configuration mode and specifies the port to configure.
Step 4	**storm-control** {**broadcast** | **multicast** | **unicast**} **level** *level-high* [*level-low*] **Example:** `Router(config-if)# Storm-control broadcast level 7`	Configures broadcast, multicast, or unicast per-port storm control. • Specify the rising threshold level for either broadcast, multicast, or unicast traffic. The storm control action occurs when traffic utilization reaches this level. • (Optional) Specify the falling threshold level. The normal transmission restarts (if the action is filtering) when traffic drops below this level.
Step 5	**storm-control action shutdown** **Example:** `Router(config-if)# Storm-control action shutdown`	Selects the **shutdown** keyword to disable the port during a storm. • The default is to filter out the traffic.
Step 6	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.
Step 7	**show storm-control** [**interface**] [**broadcast** | **multicast** | **unicast** | **history**] **Example:** `Router(config-if)# show storm-control`	Verifies your entries.

Note If any type of traffic exceeds the upper threshold limit, all of the other types of traffic will be stopped.

Disabling Per-Port Storm Control

Follow these steps to disable per-port storm control.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **no storm-control** {**broadcast** | **multicast** | **unicast**} **level** *level-high* [*level-low*]
5. **no storm-control action shutdown**
6. **end**
7. **show storm-control** {**broadcast** | **multicast** | **unicast**}

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Router(config)# interface 0/3/1`	Enters interface configuration mode and specifies the port to configure.
Step 4	**no storm-control** {**broadcast** | **multicast** | **unicast**} **level** *level-high* [*level-low*] **Example:** `Router(config-if)# no storm-control broadcast level 7`	Disables per-port storm control.
Step 5	**no storm-control action shutdown** **Example:** `Router(config-if)# no storm-control action shutdown`	Disables the specified storm control action.

	Command	Purpose
Step 6	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.
Step 7	**show storm-control** [**interface**] [{**broadcast** | **multicast** | **unicast** | **history**}] **Example:** `Router(config-if)# show storm-control`	Verifies your entries.

Configuring Stacking

Stacking is the connection of two switch modules resident in the same chassis so that they behave as a single switch. When a chassis is populated with two switch modules, the user must configure both of them to operate in stacked mode. This is done by selecting one port from each switch module and configuring it to be a stacking partner. The user must then use a cable to connect the stacking partners from each switch module to physically stack the switch modules. Any one port in a switch module can be designated as the stacking partner for that switch module.

Follow the steps below to configure a pair of ports on two different switch modules as stacking partners.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface fastethernet** *interface-id*
4. **no shutdown**
5. **switchport stacking-partner interface FastEthernet** *partner-interface-id*
6. **exit**
7. **interface fastethernet** *partner-interface-id*
8. **no shutdown**
9. **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface fastethernet** *interface-id* **Example:** `Router# interface fastethernet 0/3/1`	Enters interface configuration mode and specifies the port to configure.
Step 4	**no shutdown** **Example:** `Router# no shutdown`	Activates the interface. • This step is required only if you shut down the interface.
Step 5	**switchport stacking-partner interface fastethernet** *partner-interface-id* **Example:** `Router(config-if)# switchport stacking-partner interface FastEthernet partner-interface-id`	Selects and configures the stacking partner port. • To restore the defaults, use the **no** form of this command.
Step 6	**exit** **Example:** `Router(config-if)# exit`	Returns to privileged configuration mode.
Step 7	**interface fastethernet** *partner-interface-id* **Example:** `Router# interface fastethernet 0/3/1`	Enters interface configuration mode and specifies the partner-interface.
Step 8	**no shutdown** **Example:** `Router(config)# no shutdown`	Activates the stacking partner interface.
Step 9	**end** **Example:** `Router(config)# end`	Exits configuration mode.

Note Both stacking partner ports must have their **speed** and **duplex** parameters set to **auto**.

Caution If stacking is removed, stacked interfaces will go to **shutdown** state. Other nonstacked ports will be left unchanged.

Configuring Fallback Bridging

This section describes how to configure fallback bridging on your switch. It contains this configuration information:

- Understanding the Default Fallback Bridging Configuration, page 73
- Creating a Bridge Group, page 74
- Preventing the Forwarding of Dynamically Learned Stations, page 75
- Configuring the Bridge Table Aging Time, page 77
- Filtering Frames by a Specific MAC Address, page 78
- Adjusting Spanning-Tree Parameters, page 79
- Monitotring and Maintaining the Network, page 88

Understanding the Default Fallback Bridging Configuration

Table 2 shows the default fallback bridging configuration.

Table 2 Default Fallback Bridging Configuration

Feature	Default Setting
Bridge groups	None are defined or assigned to an interface. No VLAN-bridge STP is defined.
Switch forwards frames for stations that it has dynamically learned	Enabled.
Bridge table aging time for dynamic entries	300 seconds.
MAC-layer frame filtering	Disabled.
Spanning tree parameters:	
• Switch priority	• 32768
• Interface priority	• 128
• Interface path cost	• 10 Mbps: 100 100 Mbps: 19 1000 Mbps: 4
• Hello BPDU interval	• 2 seconds
• Forward-delay interval	• 20 seconds
• Maximum idle interval	• 30 seconds

Creating a Bridge Group

To configure fallback bridging for a set of switched virtual interfaces (SVIs), these interfaces must be assigned to bridge groups. All interfaces in the same group belong to the same bridge domain. Each SVI can be assigned to only one bridge group.

Follow the steps below to create a bridge group and assign an interface to it.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no ip routing**
4. **bridge** *bridge-group* **protocol vlan-bridge**
5. **interface** *interface-id*
6. **bridge-group** *bridge-group*
7. **end**
8. **show vlan-bridge**
9. **show running-config**
10. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**no ip routing** **Example:** `Router(config)# no ip routing`	Disables IP routing.
Step 4	**bridge** *bridge-group* **protocol vlan-bridge** **Example:** `Router(config)# bridge 100 protocol vlan-bridge`	Assigns a bridge group number and specifies the VLAN-bridge spanning-tree protocol to run in the bridge group. • The **ibm** and **dec** keywords are not supported. • For *bridge-group*, specify the bridge group number. The range is 1 to 255. • Frames are bridged only among interfaces in the same group.

	Command	Purpose
Step 5	**interface** *interface-id* **Example:** `Router(config)# interface 0/3/1`	Enters interface configuration mode and specifies the interface on which you want to assign the bridge group. • The specified interface must be an SVI: a VLAN interface that you created by using the **interface vlan** *vlan-id* global configuration command. • These ports must have IP addresses assigned to them.
Step 6	**bridge-group** *bridge-group* **Example:** `Router(config-if)# bridge-group 100`	Assigns the interface to the bridge group created in Step 2. • By default, the interface is not assigned to any bridge group. An interface can be assigned to only one bridge group.
Step 7	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.
Step 8	**show vlan-bridge** **Example:** `Router# show vlan-bridge`	(Optional) Verifies forwarding mode.
Step 9	**show running-config** **Example:** `Router# show running-config`	(Optional) Verifies your entries.
Step 10	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

To remove a bridge group, use the **no bridge** *bridge-group* **protocol vlan-bridge** global configuration command. To remove an interface from a bridge group, use the **no *bridge-group*** *bridge-group* interface configuration command.

Preventing the Forwarding of Dynamically Learned Stations

By default, the switch forwards any frames for stations that it has dynamically learned. When this activity is disabled , the switch only forwards frames whose addresses have been statically configured into the forwarding cache.

Follow the steps below to prevent the switch from forwarding frames for stations that it has dynamically learned.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no bridge** *bridge-group* **acquire**

4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**no bridge** *bridge-group* **acquire** **Example:** `Router(config)# no bridge 100 acquire`	Enables the switch to stop forwarding any frames for stations that it has dynamically learned through the discovery process and to limit frame forwarding to statically configured stations. • The switch filters all frames except those whose destined-to addresses have been statically configured into the forwarding cache. To configure a static address, use the **bridge** *bridge-group* **address** *mac-address* {**forward** | **discard**} global configuration command. • For *bridge-group*, specify the bridge group number. The range is 1 to 255.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 5	**show running-config** **Example:** `Router# show running-config`	Verifies your entry.
Step 6	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entry in the configuration file.

To cause the switch to forward frames to stations that it has dynamically learned, use the **bridge** *bridge-group* **acquire** global configuration command.

Configuring the Bridge Table Aging Time

A switch forwards, floods, or drops packets based on the bridge table. The bridge table maintains both static and dynamic entries. Static entries are entered by you. Dynamic entries are entered by the bridge learning process. A dynamic entry is automatically removed after a specified length of time, known as aging time, from the time the entry was created or last updated.

If you are likely to move hosts on a switched network, decrease the aging time to enable the switch to quickly adapt to the change. If hosts on a switched network do not continuously send packets, increase the aging time to keep the dynamic entries for a longer time and thus reduce the possibility of flooding when the hosts send again.

Follow the steps below to configure the aging time.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **bridge** *bridge-group* **aging-time** *seconds*
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**bridge** *bridge-group* **aging-time** *seconds* **Example:** `Router(config)# bridge 100 aging-time 10000`	Specifies the length of time that a dynamic entry remains in the bridge table from the time the entry was created or last updated. • For *bridge-group*, specify the bridge group number. The range is 1 to 255. • For *seconds*, enter a number from 0 to 1000000. The default is 300 seconds.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.

	Command	Purpose
Step 5	**show running-config** **Example:** `Router# show running-config`	Verifies your entry.
Step 6	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entry in the configuration file.

To return to the default aging-time interval, use the **no bridge** *bridge-group* **aging-time** global configuration command.

Filtering Frames by a Specific MAC Address

A switch examines frames and sends them through the internetwork according to the destination address; a switch does not forward a frame back to its originating network segment. You can use the software to configure specific administrative filters that filter frames based on information other than the paths to their destinations.

You can filter frames with a particular MAC-layer station destination address. Any number of addresses can be configured in the system without a performance penalty.

Follow the steps below to filter by the MAC-layer address.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **bridge** *bridge-group* **address** *mac-address* {**forward** | **discard**} [*interface-id*]
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command	Purpose
Step 3	**show running-config** **Example:** `Router: show running-config`	Verifies your entry.
Step 4	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entry in the configuration file.

To disable the frame forwarding ability, use the **no bridge** *bridge-group* **address** *mac-address* global configuration command.

Adjusting Spanning-Tree Parameters

You might need to adjust certain spanning-tree parameters if the default values are not suitable for your switch configuration. Parameters affecting the entire spanning tree are configured with variations of the **bridge** global configuration command. Interface-specific parameters are configured with variations of the **bridge-group** interface configuration command.

You can adjust spanning-tree parameters by performing any of the tasks in these sections:

- Changing the Switch Priority, page 79
- Changing the Interface Priority, page 81
- Assigning a Path Cost, page 82
- Adjusting BPDU Intervals, page 83
- Adjusting the Interval Between Hello BPDUs, page 83
- Changing the Forward-Delay Interval, page 84
- Changing the Maximum-Idle Interval, page 86
- Disabling the Spanning Tree on an Interface, page 87

Note Only network administrators with a good understanding of how switches and STP function should make adjustments to spanning-tree parameters. Poorly planned adjustments can have a negative impact on performance. A good source on switching is the IEEE 802.1d specification; for more information, refer to the "References and Recommended Reading" appendix in the *Cisco IOS Configuration Fundamentals Command Reference*, Release 12.2.

Changing the Switch Priority

You can globally configure the priority of an individual switch when two switches tie for position as the root switch, or you can configure the likelihood that a switch will be selected as the root switch. This priority is determined by default; however, you can change it.

Follow the steps below to change the switch priority.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **bridge** *bridge-group* **priority** *number*
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**bridge** *bridge-group* **priority** *number* **Example:** `Router(config)# bridge 100 priority 5`	Changes the priority of the switch. • For *bridge-group*, specify the bridge group number. The range is 1 to 255. • For *number*, enter a number from 0 to 65535. The default is 32768. The lower the number, the more likely the switch will be chosen as the root.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.
Step 5	**show running-config** **Example:** `Router: show running-config`	Verifies your entry.
Step 6	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entry in the configuration file.

This command does not have a **no** form. To return to the default setting, use the **bridge** *bridge-group* **priority** *number* global configuration command, and set the priority to the default value. To change the priority on an interface, use the **bridge-group priority** interface configuration command (described in the next section).

Changing the Interface Priority

You can change the priority for an interface. When two switches tie for position as the root switch, you configure an interface priority to break the tie. The switch with the lower interface value is elected.

Follow the steps below to change the interface priority.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **bridge-group** *bridge-group* **priority** *number*
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Router(config)# interface 0/3/1`	Enters interface configuration mode and specifies the interface to set the priority.
Step 4	**bridge** *bridge-group* **priority** *number* **Example:** `Router(config-if)# bridge 100 priority 4`	Changes the prioriyt of the bridge.
Step 5	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.

	Command	Purpose
Step 6	**show running-config** **Example:** `Router: show running-config`	Verifies your entry.
Step 7	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entry in the configuration file.

To return to the default setting, use the **bridge-group** *bridge-group* **priority** *number* interface configuration command.

Assigning a Path Cost

Each interface has a path cost associated with it. By convention, the path cost is 1000/data rate of the attached LAN, in Mbps.

Follow the steps below to assign a path cost.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **bridge-group** *bridge-group* **path-cost** cost
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command	Purpose
Step 3	**interface** *interface-id* **Example:** `Router(config)# interface 0/3/1`	Enters interface configuration mode and specifies the interface to set the priority.
Step 4	**bridge** *bridge-group* **path-costs** *cost* **Example:** `Router(config-if)# bridge 100 pathcost 4`	Changes the path cost.
Step 5	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.
Step 6	**show running-config** **Example:** `Router: show running-config`	Verifies your entry.
Step 7	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entry in the configuration file.

To return to the default path cost, use the **no bridge-group** *bridge-group* **path-cost** *cost* interface configuration command.

Adjusting BPDU Intervals

You can adjust bridge protocol data unit (BPDU) intervals as described in these sections:

- Adjusting the Interval Between Hello BPDUs, page 83
- Changing the Forward-Delay Interval, page 84
- Changing the Maximum-Idle Interval, page 86

Note Each switch in a spanning tree adopts the interval between hello BPDUs, the forward delay interval, and the maximum idle interval parameters of the root switch, regardless of what its individual configuration might be.

Adjusting the Interval Between Hello BPDUs

Follow the steps below to adjust the interval between hello BPDUs.

SUMMARY STEPS

1. **enable**
2. **configure terminal**

3. **bridge** *bridge-group* **hello-time** *seconds*
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**bridge** *bridge-group* **hello-time** *seconds* **Example:** `Router(config-if)# bridge 100 hello-time 5`	Specifies the interval between hello BPDUs. • For *bridge-group*, specify the bridge group number. The range is 1 to 255. • For *seconds*, enter a number from 1 to 10. The default is 2 seconds.
Step 4	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.
Step 5	**show running-config** **Example:** `Router: show running-config`	Verifies your entry.
Step 6	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entry in the configuration file.

To return to the default setting, use the **no bridge** *bridge-group* **hello-time** global configuration command.

Changing the Forward-Delay Interval

The forward-delay interval is the amount of time spent listening for topology change information after an interface has been activated for switching and before forwarding actually begins.

Follow the steps below to change the forward-delay interval.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **bridge** *bridge-group* **forward-time** *seconds*
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**bridge** *bridge-group* **forward-time** *seconds* **Example:** `Router(config-if)# bridge 100 forward-time 25`	Specifies the forward-delay interval. • For *bridge-group*, specify the bridge group number. The range is 1 to 255. • For *seconds*, enter a number from 10 to 200. The default is 20 seconds.
Step 4	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.
Step 5	**show running-config** **Example:** `Router: show running-config`	Verifies your entry.
Step 6	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entry in the configuration file.

To return to the default setting, use the **no bridge** *bridge-group* **forward-time** *seconds* global configuration command.

Changing the Maximum-Idle Interval

If a switch does not hear BPDUs from the root switch within a specified interval, it recomputes the spanning-tree topology.

Follow the steps below to change the maximum-idle interval (maximum aging time).

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **bridge** *bridge-group* **max-age** *seconds*
4. **end**
5. **show running-config**
6. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**bridge** *bridge-group* **max-age** *seconds* **Example:** `Router(config-if)# bridge 100 forward-time 25`	Specifies the interval the switch waits to hear BPDUs from the root switch. • For *bridge-group*, specify the bridge group number. The range is 1 to 255. • For *seconds*, enter a number from 10 to 200. The default is 30 seconds.
Step 4	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.
Step 5	**show running-config** **Example:** `Router: show running-config`	Verifies your entry.
Step 6	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entry in the configuration file.

To return to the default setting, use the **no bridge** *bridge-group* **max-age** global configuration command.

Disabling the Spanning Tree on an Interface

When a loop-free path exists between any two switched subnetworks, you can prevent BPDUs generated in one switching subnetwork from impacting devices in the other switching subnetwork, yet still permit switching throughout the network as a whole. For example, when switched LAN subnetworks are separated by a WAN, BPDUs can be prevented from traveling across the WAN link.

Follow the steps below to disable spanning tree on an interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **bridge-group** *bridge-group* **spanning-disabled**
5. **end**
6. **show running-config**
7. **copy running-config startup-config**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Router(config)# interface 0/3/1`	Enters interface configuration mode and specifies the interface to set the priority.
Step 4	**bridge-group** *bridge-group* **spanning-disabled** **Example:** `Router(config-if)# bridge 100 spanning-disabled`	Disables spanning tree on the interface. • For *bridge-group*, specify the bridge group number. The range is 1 to 255.
Step 5	**end** **Example:** `Router(config-if)# end`	Returns to privileged EXEC mode.

	Command	Purpose
Step 6	**show running-config** **Example:** `Router: show running-config`	Verifies your entry.
Step 7	**copy running-config startup-config** **Example:** `Router# copy running-config startup-config`	(Optional) Saves your entry in the configuration file.

To reenable spanning tree on the interface, use the **no bridge-group** *bridge-group* **spanning-disabled** interface configuration command.

Monitotring and Maintaining the Network

To monitor and maintain the network, use one or more of the following privileged EXEC commands.

Command	Purpose
clear bridge *bridge-group*	Removes any learned entries from the forwarding database and clears the transmit and receive counts for any statically configured entries.
show bridge [*bridge-group*]	Displays details about the bridge group.
show bridge [*bridge-group*] [*interface-id*] [*address*] [**group**] [**verbose**]	Displays classes of entries in the bridge forwarding database.

Configuring Separate Voice and Data Subnets

For ease of network administration and increased scalability, network managers can configure the HWICs to support Cisco IP phones such that the voice and data traffic reside on separate subnets. You should always use separate VLANs when you are able to segment the existing IP address space of your branch office.

User priority bits in the 802.1p portion of the 802.1Q standard header are used to provide prioritization in Ethernet switches. This is a vital component in designing Cisco AVVID networks.

The HWICs provides the performance and intelligent services of Cisco IOS software for branch office applications. The HWICs can identify user applications—such as voice or multicast video—and classify traffic with the appropriate priority levels.

Note Refer to the *Cisco AVVID QoS Design Guide* for more information on how to implement end-to-end QoS as you deploy Cisco AVVID solutions.

Follow these steps to automatically configure Cisco IP phones to send voice traffic on the voice VLAN ID (VVID) on a per-port basis (see the "Voice Traffic and VVID" section on page 89).

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **switchport mode trunk**
5. **switchport voice vlan** *vlan-id*

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	`interface interface-id` **Example:** `Router(config)#` interface 0/2/1	Enters the interface configuration mode and the port to be configured (for example, interface fa0/3/1).

Step 4	`switchport mode trunk`
	
	Example:
	`Router(config-if)# switchport mode trunk`
		Configures the port to trunk mode.

Step 5	`switchport voice vlan vlan-id`
	
	Example:
	`Router(config-if)# switchport voice vlan 100`
		Configures the voice port with a VVID that will be used exclusively for voice traffic.

Voice Traffic and VVID

The HWICs can automatically configure voice VLAN. This capability overcomes the management complexity of overlaying a voice topology onto a data network while maintaining the quality of voice traffic. With the automatically configured voice VLAN feature, network administrators can segment phones into separate logical networks, even though the data and voice infrastructure is physically the same. The voice VLAN feature places the phones into their own VLANs without the need for end-user intervention. A user can plug the phone into the switch, and the switch provides the phone with the necessary VLAN information.

Configuring a Single Subnet for Voice and Data

For network designs with incremental IP telephony deployment, network managers can configure the HWICs so that the voice and data traffic coexist on the same subnet. This might be necessary when it is impractical either to allocate an additional IP subnet for IP phones or to divide the existing IP address space into an additional subnet at the remote branch, it might be necessary to use a single IP address space for branch offices. (This is one of the simpler ways to deploy IP telephony.)

This configuration approach must address two key considerations:

- Network managers should ensure that existing subnets have enough available IP addresses for the new Cisco IP phones, each of which requires a unique IP address.
- Administering a network with a mix of IP phones and workstations on the same subnet might pose a challenge.

Beginning in privileged EXEC mode, follow these steps to automatically configure Cisco IP phones to send voice and data traffic on the same VLAN.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **switchport access vlan** *vlan-id*
5. **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Router(config)#` interface 0/2/1	Enters the interface configuration mode and the port to be configured (e.g., interface fa0/1/1).

	Command	Purpose
Step 4	**switchport access vlan** *vlan-id* **Example:** `Router(config-if)#` switchport access vlan 100	Sets the native VLAN for untagged traffic. • The value of *vlan-id* represents the ID of the VLAN that is sending and receiving untagged traffic on the port. Valid IDs are from 1 to 1001. Leading zeroes are not permitted.
Step 5	**end** **Example:** `Router# end`	Returns to the privileged EXEC mode.

Verifying Switchport Configuration

Use the **show run interface** command to verify the switchport configuration.

```
Router# show run interface interface-id
```

Use the **write memory** command to save the current configuration in flash memory.

```
Router# write memory
```

Managing the EtherSwitch HWIC

This section describes how to perform basic management tasks on the HWICs with the Cisco IOS command line interface. You might find this information useful when you configure the switch for the purposed described in the preceding sections.

The following topics are included:

- Adding Trap Managers, page 91
- Configuring IP Information, page 92
- Enabling Switch Port Analyzer, page 96
- Managing the ARP Table, page 97
- Managing the MAC Address Tables, page 97
- Removing Dynamic Addresses, page 99
- Adding Secure Addresses, page 100
- Configuring Static Addresses, page 102
- Clearing All MAC Address Tables, page 104

Adding Trap Managers

A trap manager is a management station that receives and processes traps. When you configure a trap manager, community strings for each member switch must be unique. If a member switch has an IP address assigned to it, the management station accesses the switch by using its assigned IP address.

By default, no trap manager is defined, and no traps are issued.

Follow these steps to add a trap manager and community string.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **snmp-server host** *ip-address traps* **snmp** *vlan-membership*
4. **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**snmp-server host** *ip-address traps* **snmp** *vlan-membership* **Example:** `Router(config)# snmp-server host 172.16.128.263 traps1 snmp vlancommunity1`	Enters the trap manager IP address, community string, and the traps to generate.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.

Verifying Trap Managers

Use the **show running-config** command to verify that the information was entered correctly by displaying the running configuration:

```
Router# show running-config
```

Configuring IP Information

This section describes how to assign IP information on the HWICs. The following topics are included:

- Assigning IP Information to the Switch, page 92
- Specifying a Domain Name and Configuring the DNS, page 95

Assigning IP Information to the Switch

You can use a BOOTP server to automatically assign IP information to the switch; however, the BOOTP server must be set up in advance with a database of physical MAC addresses and corresponding IP addresses, subnet masks, and default gateway addresses. In addition, the switch must be able to access the BOOTP server through one of its ports. At startup, a switch without an IP address requests the

information from the BOOTP server; the requested information is saved in the switch running the configuration file. To ensure that the IP information is saved when the switch is restarted, save the configuration by entering the **write memory** command in privileged EXEC mode.

You can change the information in these fields. The mask identifies the bits that denote the network number in the IP address. When you use the mask to subnet a network, the mask is then referred to as a subnet mask. The broadcast address is reserved for sending messages to all hosts. The CPU sends traffic to an unknown IP address through the default gateway.

Follow these steps to enter the IP information.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *vlan_id*
4. **ip address** *ip-address subnet-mask*
5. **exit**
6. **ip default-gateway** *ip-address*
7. **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** *vlan_id* **Example:** `Router(config)# interface vlan 1`	Enters interface configuration mode and specifies the VLAN to which the IP information is assigned. • VLAN 1 is the management VLAN, but you can configure any VLAN from IDs 1 to 1001.
Step 4	**ip address** *ip-address subnet-mask* **Example:** `Router(config-if)# ip address 192.0.2.10 255.255.255.255`	Enters the IP address and subnet mask.
Step 5	**exit** **Example:** `Router(config)# exit`	Returns to global configuration mode.

	Command	Purpose
Step 6	**ip default-gateway** *ip-address* **Example:** `Router# ip default-gateway 192.0.2.20`	Enters the IP address of the default router.
Step 7	**end** **Example:** `Router# end`	Returns to privileged EXEC mode.

Use the following procedure to remove the IP information from a switch.

Note Using the **no ip address** command in configuration mode disables the IP protocol stack and removes the IP information. Cluster members without IP addresses rely on the IP protocol stack being enabled.

Use these steps to remove an IP address.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *vlan_id*
4. **no ip address**
5. **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface** vlan_id **Example:** `Router(config)# interface vlan 1`	Enters interface configuration mode, and enters the VLAN to which the IP information is assigned. VLAN 1 is the management VLAN, but you can configure any VLAN from IDs 1 to 1001.

	Command	Purpose
Step 4	**no ip address** **Example:** `Router(config-subif)# no ip address`	Removes the IP address and subnet mask.
Step 5	end **Example:** `Router(config-subif)# end`	Returns to privileged EXEC mode.

Caution **If you are removing the IP address through a telnet session, your connection to the switch will be lost.**

Specifying a Domain Name and Configuring the DNS

Each unique IP address can have a host name associated with it. The Cisco IOS software maintains an EXEC mode and related Telnet support operations. This cache speeds the process of converting names to addresses.

IP defines a hierarchical naming scheme that allows a device to be identified by its location or domain. Domain names are pieced together with periods (.) as the delimiting characters. For example, Cisco Systems is a commercial organization that IP identifies by a *com* domain name, so its domain name is *cisco.com*. A specific device in this domain, the FTP system, for example, is identified as *ftp.cisco.com*.

To track domain names, IP has defined the concept of a domain name server (DNS), the purpose of which is to hold a cache (or database) of names mapped to IP addresses. To map domain names to IP addresses, you must first identify the host names and then specify a name server and enable the DNS, the Internet's global naming scheme that uniquely identifies network devices.

Specifying the Domain Name

You can specify a default domain name that the software uses to complete domain name requests. You can specify either a single domain name or a list of domain names. When you specify a domain name, any IP host name without a domain name has that domain name appended to it before being added to the host table.

Specifying a Name Server

You can specify up to six hosts that can function as a name server to supply name information for the DNS.

Enabling the DNS

If your network devices require connectivity with devices in networks for which you do not control name assignment, you can assign device names that uniquely identify your devices within the entire internetwork. The Internet's global naming scheme, the DNS, accomplishes this task. This service is enabled by default.

Enabling Switch Port Analyzer

You can monitor traffic on a given port by forwarding incoming and outgoing traffic on the port to another port in the same VLAN. A Switch Port Analyzer (SPAN) port cannot monitor ports in a different VLAN, and a SPAN port must be a static-access port. Any number of ports can be defined as SPAN ports, and any combination of ports can be monitored. SPAN is supported for up to 2 sessions.

Follow the steps below to enable SPAN.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **monitor session** *session-id* {**destination** | **source**} {**interface** | **vlan** *interface-id* | *vlan-id*}} [**,** | **-** | **both** | **tx** | **rx**]
4. **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**monitor session** session-id {**destination** | **source**} {**interface** | **vlan** *interface-id* | *vlan-id*}} [**,** | **-** | **both** | **tx** | **rx**] **Example:** Router(config)# **monitor session** session-id {**destination** | **source**} {**interface** | **vlan** *interface-id* | *vlan-id*}} [**,** | **-** | **both** | **tx** | **rx**]	Enables port monitoring for a specific session (“*number”).* • Optionally, supply a SPAN *destination* interface and a *source* interface.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.

Disabling SPAN

Follow these steps to disable SPAN.

SUMMARY STEPS

1. **enable**

2. **configure terminal**
3. **no monitor session** *session-id*
4. **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**no monitor session** *session-id* **Example:** Router(config)# no monitor session 37	Disables port monitoring for a specific session.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.

Managing the ARP Table

To communicate with a device (on Ethernet, for example), the software first must determine the 48-bit MAC or local data link address of that device. The process of determining the local data link address from an IP address is called *address resolution*.

The Address Resolution Protocol (ARP) associates a host IP address with the corresponding media or MAC addresses and VLAN ID. Taking an IP address as input, ARP determines the associated MAC address. Once a MAC address is determined, the IP-MAC address association is stored in an ARP cache for rapid retrieval. Then the IP datagram is encapsulated in a link-layer frame and sent over the network. Encapsulation of IP datagrams and ARP requests and replies on IEEE 802 networks other than Ethernet is specified by the Subnetwork Access Protocol (SNAP). By default, standard Ethernet-style ARP encapsulation (represented by the **arpa** keyword) is enabled on the IP interface.

When you manually add entries to the ARP table by using the CLI, you must be aware that these entries do not age and must be manually removed.

Managing the MAC Address Tables

This section describes how to manage the MAC address tables on the HWICs. The following topics are included:

- Understanding MAC Addresses and VLANs, page 98
- Changing the Address Aging Time, page 98

- Configuring the Aging Time, page 98
- Verifying Aging-Time Configuration, page 99

The switch uses the MAC address tables to forward traffic between ports. All MAC addresses in the address tables are associated with one or more ports. These MAC tables include the following types of addresses:

- Dynamic address—A source MAC address that the switch learns and then drops when it is not in use.
- Secure address—A manually entered unicast address that is usually associated with a secured port. Secure addresses do not age.
- Static address—A manually entered unicast or multicast address that does not age and that is not lost when the switch resets.

The address tables list the destination MAC address and the associated VLAN ID, module, and port number associated with the address. The following shows an example of a list of addresses as they would appear in the dynamic, secure, or static address table.

```
Router# show mac-address-table

Destination Address  Address Type  VLAN  Destination Port
-------------------  ------------  ----  --------------------
000a.000b.000c          Secure      1      FastEthernet0/1/8
000d.e105.cc70          Self        1      Vlan1
00aa.00bb.00cc          Static      1      FastEthernet0/1/0
```

Understanding MAC Addresses and VLANs

All addresses are associated with a VLAN. An address can exist in more than one VLAN and have different destinations in each. Multicast addresses, for example, could be forwarded to port 1 in VLAN 1 and ports 9, 10, and 11 in VLAN 5.

Each VLAN maintains its own logical address table. A known address in one VLAN is unknown in another until it is learned or statically associated with a port in the other VLAN. An address can be secure in one VLAN and dynamic in another. Addresses that are statically entered in one VLAN must be static addresses in all other VLANs.

Changing the Address Aging Time

Dynamic addresses are source MAC addresses that the switch learns and then drops when they are not in use. Use the Aging Time field to define how long the switch retains unseen addresses in the table. This parameter applies to all VLANs.

Configuring the Aging Time

Setting too short an aging time can cause addresses to be prematurely removed from the table. Then when the switch receives a packet for an unknown destination, it floods the packet to all ports in the same VLAN as the receiving port. This unnecessary flooding can impact performance. Setting too long an aging time can cause the address table to be filled with unused addresses; it can cause delays in establishing connectivity when a workstation is moved to a new port.

Follow these steps to configure the dynamic address table aging time.

SUMMARY STEPS

1. **enable**
2. **configure terminal**

3. **mac-address-table aging-time** *seconds*
4. **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mac-address-table aging-time** *seconds* **Example:** `Router(config)# mac-address-table aging-time 30000`	Enters the number of seconds that dynamic addresses are to be retained in the address table. • Valid entries are from 10 to 1000000.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.

Verifying Aging-Time Configuration

Use the **show mac-address-table aging-time** command to verify configuration:

```
Router# show mac-address-table aging-time
```

Removing Dynamic Addresses

Follow these steps to remove a dynamic address entry.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no mac-address-table dynamic** *hw-addr*
4. **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**no mac-address-table dynamic** *hw-addr* **Example:** `Router(config)# no mac-address-table dynamic 0100.5e05.0505`	Enters the MAC address to be removed from dynamic MAC address table.
Step 4	end **Example:** Router(config)# `end`	Returns to privileged EXEC mode.

You can remove all dynamic entries by using the **clear mac-address-table dynamic** command in privileged EXEC mode.

Verifying Dynamic Addresses

Use the **show mac-address-table dynamic** command to verify configuration:

```
Router# show mac-address-table dynamic
```

Adding Secure Addresses

The secure address table contains secure MAC addresses and their associated ports and VLANs. A secure address is a manually entered unicast address that is forwarded to only one port per VLAN. If you enter an address that is already assigned to another port, the switch reassigns the secure address to the new port.

You can enter a secure port address even when the port does not yet belong to a VLAN. When the port is later assigned to a VLAN, packets destined for that address are forwarded to the port.

Follow these steps to add a secure address.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mac-address-table secure address** *hw-addr* **interface** *interface-id* **vlan** *vlan-id*
4. **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mac-address-table secure address** *hw-addr* **interface** *interface-id* **vlan** *vlan-id* **Example:** `Router(config)#` mac-address-table secure address 0100.5e05.0505 interface 0/3/1 vlan vlan 1	Enters the MAC address, its associated port, and the VLAN ID.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.

Follow these steps to remove a secure address.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no mac-address-table secure** *hw-addr* **vlan** *vlan-id*
4. **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command	Purpose
Step 3	**no mac-address-table secure** *hw-addr* **vlan** *vlan-id* **Example:** `Router(config)# no` mac-address-table secure address 0100.5e05.0505 vlan vlan 1	Enters the secure MAC address, its associated port, and the VLAN ID to be removed.
Step 4	**end** **Example:** `Router(config)#` end	Returns to privileged EXEC mode.

You can remove all secure addresses by using the **clear mac-address-table secure** command in privileged EXEC mode.

Verifying Secure Addresses

Use the **show mac-address-table secure** command to verify configuration:

```
Router# show mac-address-table secure
```

Configuring Static Addresses

A static address has the following characteristics:

- It is manually entered in the address table and must be manually removed.
- It can be a unicast or multicast address.
- It does not age and is retained when the switch restarts.

Because all ports are associated with at least one VLAN, the switch acquires the VLAN ID for the address from the ports that you select on the forwarding map. A static address in one VLAN must be a static address in other VLANs. A packet with a static address that arrives on a VLAN where it has not been statically entered is flooded to all ports and not learned.

Follow these steps to add a static address.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mac-address-table static** *hw-addr* [**interface**] *interface-id* [**vlan**] *vlan-id*
4. **end**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**mac-address-table static** *hw-addr* [**interface**] *interface-id* [**vlan**] *vlan-id* **Example:** `Router(config)#` mac-address-table static 0100.5e05.0505 interface 0/3/1 vlan vlan 1	Enters the static MAC address, the interface, and the VLAN ID of those ports.
Step 4	**end** **Example:** `Router(config)# end`	Returns to privileged EXEC mode.

Follow these steps to remove a static address.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **no mac-address-table static** *hw-addr* [**interface**] *interface-id* [**vlan**] *vlan-id*
4. **end**

DETAILED STEPS

:

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command	Purpose
Step 3	**no mac-address-table static** *hw-addr* [**interface**] *interface-id* [**vlan**] *vlan-id* **Example:** Router(config)# no mac-address-table static 0100.5e05.0505 interface 0/3/1 vlan vlan	Enters the static MAC address, the interface, and the VLAN ID of the port to be removed.
Step 4	end **Example:** Router(config)# end	Returns to privileged EXEC mode.

You can remove all secure addresses by using the **clear mac-address-table static** command in privileged EXEC mode.

Verifying Static Addresses

Use the **show mac-address-table static** command to verify configuration:

```
Router # show mac-address-table static

Static Address Table
Destination Address  Address Type  VLAN  Destination Port
-------------------  ------------  ----  --------------------
000a.000b.000c          Static        1     FastEthernet0/1/0
```

Clearing All MAC Address Tables

To remove all addresses, use the **clear mac-address** command in privileged EXEC mode:

Command	Purpose
Router# clear mac-address-table	Enters to clear all MAC address tables.

Configuration Examples for EtherSwitch HWICs

This section provides the following configuration examples:

- Range of Interface: Examples, page 105
- Optional Interface Feature: Examples, page 105
- Stacking: Example, page 106
- VLAN Configuration: Example, page 106
- VLAN Trunking Using VTP: Example, page 106
- Spanning Tree: Examples, page 107
- MAC Table Manipulation: Example, page 110
- Switched Port Analyzer (SPAN) Source: Examples, page 110
- IGMP Snooping: Example, page 110

- Storm-Control: Example, page 112
- Ethernet Switching: Examples, page 112

Range of Interface: Examples

- Single Range Configuration: Example, page 105
- Range Macro Definition: Example, page 105

Single Range Configuration: Example

The following example shows all Fast Ethernet interfaces on an HWIC-4ESW in slot 2 being reenabled:

```
Router(config)# interface range fastEthernet 0/3/0 - 8
Router(config-if-range)# no shutdown
Router(config-if-range)#
*Mar  21 14:01:21.474: %LINK-3-UPDOWN: Interface FastEthernet0/3/0, changed state to up
*Mar  21 14:01:21.490: %LINK-3-UPDOWN: Interface FastEthernet0/3/1, changed state to up
*Mar  21 14:01:21.502: %LINK-3-UPDOWN: Interface FastEthernet0/3/2, changed state to up
*Mar  21 14:01:21.518: %LINK-3-UPDOWN: Interface FastEthernet0/3/3, changed state to up
*Mar  21 14:01:21.534: %LINK-3-UPDOWN: Interface FastEthernet0/3/4, changed state to up
*Mar  21 14:01:21.546: %LINK-3-UPDOWN: Interface FastEthernet0/3/5, changed state to up
*Mar  21 14:01:21.562: %LINK-3-UPDOWN: Interface FastEthernet0/3/6, changed state to up
*Mar  21 14:01:21.574: %LINK-3-UPDOWN: Interface FastEthernet0/3/7, changed state to up
*Mar  21 14:01:21.590: %LINK-3-UPDOWN: Interface FastEthernet0/3/8, changed state to up
Router(config-if-range)#
```

Range Macro Definition: Example

The following example shows an interface-range macro named enet_list being defined to select Fast Ethernet interfaces 0/1/0 through 0/1/3:

```
Router(config)# define interface-range enet_list fastethernet 0/1/0 - 0/1/3
Router(config)#
```

The following example shows how to change to the interface-range configuration mode using the interface-range macro enet_list:

```
Router(config)# interface range macro enet_list
```

Optional Interface Feature: Examples

- Interface Speed: Example, page 105
- Setting the Interface Duplex Mode: Example, page 106
- Adding a Description for an Interface: Example, page 106

Interface Speed: Example

The following example shows the interface speed being set to 100 Mbps on Fast Ethernet interface 0/3/7:

```
Router(config)# interface fastethernet 0/3/7
Router(config-if)# speed 100
```

Setting the Interface Duplex Mode: Example

The following example shows the interface duplex mode being set to full on Fast Ethernet interface 0/3/7:

```
Router(config)# interface fastethernet 0/3/7
Router(config-if)# duplex full
```

Adding a Description for an Interface: Example

The following example shows how to add a description of Fast Ethernet interface 0/3/7:

```
Router(config)# interface fastethernet 0/3/7
Router(config-if)# description Link to root switch
```

Stacking: Example

The following example shows how to stack two HWICs.

```
Router(config)# interface FastEthernet 0/1/8
Router(config-if)# no shutdown
Router(config-if)# switchport stacking-partner interface FastEthernet 0/3/8
Router(config-if)# interface FastEthernet 0/3/8
Router(config-if)# no shutdown
```

Note In practice, the command **switchport stacking-partner interface FastEthernet** *0/partner-slot/partner-port* needs to be executed for only one of the stacked ports. The other port will be automatically configured as a stacking port by the Cisco IOS software. The command **no shutdown**, however, must be executed for both of the stacked ports.

VLAN Configuration: Example

The following example shows how to configure inter-VLAN routing:

```
Router# vlan database
Router(vlan)# vlan 1
Router(vlan)# vlan 2
Router(vlan)# exit
Router# configure terminal
Router(config)# interface vlan 1
Router(config-if)# ip address 10.1.1.1 255.255.255.0
Router(config-if)# no shut
Router(config-if)# interface vlan 2
Roouter(config-if)# ip address 10.2.2.2 255.255.255.0
Router(config-if)# no shut
Router(config-if)# interface FastEthernet 0/1/0
Router(config-if)# switchport access vlan 1
Router(config-if)# interface Fast Ethernet 0/1/1
Router(config-if)# switchport access vlan 2
Router(config-if)# exit
```

VLAN Trunking Using VTP: Example

The following example shows how to configure the switch as a VTP server:

```
Router# vlan database
Router(vlan)# vtp server
Setting device to VTP SERVER mode.
Router(vlan)# vtp domain Lab_Network
Setting VTP domain name to Lab_Network
Router(vlan)# vtp password WATER
Setting device VLAN database password to WATER.
Router(vlan)# exit
APPLY completed.
Exiting....
Router#
```

The following example shows how to configure the switch as a VTP client:

```
Router# vlan database
Router(vlan)# vtp client
Setting device to VTP CLIENT mode.
Router(vlan)# exit

In CLIENT state, no apply attempted.
Exiting....
Router#
```

The following example shows how to configure the switch as VTP transparent:

```
Router# vlan database
Router(vlan)# vtp transparent
Setting device to VTP TRANSPARENT mode.
Router(vlan)# exit
APPLY completed.
Exiting....
Router#
```

Spanning Tree: Examples

- Spanning-Tree Interface and Spanning-Tree Port Priority: Example, page 107
- Spanning-Tree Port Cost: Example, page 108
- Bridge Priority of a VLAN: Example, page 109
- Hello Time: Example, page 109
- Forward-Delay Time for a VLAN: Example, page 109
- Maximum Aging Time for a VLAN: Example, page 109
- Spanning Tree: Examples, page 109
- Spanning Tree Root: Example, page 110

Spanning-Tree Interface and Spanning-Tree Port Priority: Example

The following example shows the VLAN port priority of an interface being configured:

```
Router# configure terminal
Router(config)# interface fastethernet 0/3/2
Router(config-if)# spanning-tree vlan 20 port-priority 64
Router(config-if)# end
Router#
```

The following example shows how to verify the configuration of VLAN 200 on the interface when it is configured as a trunk port:

```
Router# show spanning-tree vlan 20

 VLAN20 is executing the ieee compatible Spanning Tree protocol
  Bridge Identifier has priority 32768, address 00ff.ff90.3f54
  Configured hello time 2, max age 20, forward delay 15
  Current root has priority 32768, address 00ff.ff10.37b7
  Root port is 33 (FastEthernet0/3/2), cost of root path is 19
  Topology change flag not set, detected flag not set
  Number of topology flags 0 last change occurred 00:05:50 ago
  Times: hold 1, topology change 35, notification 2
     hello 2, max age 20, forward delay 15
  Timers: hello 0, topology change 0, notification 0, aging 0

 Port 33 (FastEthernet0/3/2) of VLAN20 is forwarding
  Port path cost 18, Port priority 64, Port Identifier 64.33
  Designated root has priority 32768, address 00ff.ff10.37b7
  Designated bridge has priority 32768, address 00ff.ff10.37b7
  Designated port id is 128.13, designated path cost 0
  Timers: message age 2, forward delay 0, hold 0
  Number of transitions to forwarding state: 1
  BPDU: sent 1, received 175
Router#
```

Spanning-Tree Port Cost: Example

The following example shows how to change the spanning-tree port cost of a Fast Ethernet interface:

```
Router# configure terminal
Router(config)# interface fastethernet 0/3/2
Router(config-if)# spanning-tree cost 18
Router(config-if)# end
Router#

Router# show run interface fastethernet0/3/2
Building configuration...

Current configuration: 140 bytes
!
interface FastEthernet0/3/2
 switchport access vlan 20
  no ip address
  spanning-tree vlan 20 port-priorityy 64
  spanning-tree cost 18
end
```

The following example shows how to verify the configuration of the interface when it is configured as an access port:

```
Router# show spanning-tree interface fastethernet 0/3/2
 Port 33 (FastEthernet0/3/2) of VLAN20 is forwarding
  Port path cost 18, Port priority 64, Port Identifier 64.33
  Designated root has priority 32768, address 00ff.ff10.37b7
  Designated bridge has priority 32768, address 00ff.ff10.37b7
  Designated port id is 128.13, designated path cost 0
  Timers: message age 2, forward delay 0, hold 0
  Number of transitions to forwarding state: 1
  BPDU: sent 1, received 175
Router#
```

Bridge Priority of a VLAN: Example

The following example shows the bridge priority of VLAN 20 being configured to 33792:

```
Router# configure terminal
Router(config)# spanning-tree vlan 20 priority 33792
Router(config)# end
Router#
```

Hello Time: Example

The following example shows the hello time for VLAN 20 being configured to 7 seconds:

```
Router# configure terminal
Router(config)# spanning-tree vlan 20 hello-time 7
Router(config)# end
Router#
```

Forward-Delay Time for a VLAN: Example

The following example shows the forward delay time for VLAN 20 being configured to 21 seconds:

```
Router# configure terminal
Router(config)# spanning-tree vlan 20 forward-time 21
Router(config)# end
Router#
```

Maximum Aging Time for a VLAN: Example

The following example configures the maximum aging time for VLAN 20 to 36 seconds:

```
Router# configure terminal
Router(config)# spanning-tree vlan 20 max-age 36
Router(config)# end
Router#
```

Spanning Tree: Examples

The following example shows spanning tree being enabled on VLAN 20:

```
Router# configure terminal
Router(config)# spanning-tree vlan 20
Router(config)# end
Router#
```

Note Because spanning tree is enabled by default, issuing a **show running** command to view the resulting configuration will not display the command you entered to enable spanning tree.

The following example shows spanning tree being disabled on VLAN 20:

```
Router# configure terminal
Router(config)# no spanning-tree vlan 20
Router(config)# end
Router#
```

Spanning Tree Root: Example

The following example shows the switch being configured as the root bridge for VLAN 10, with a network diameter of 4:

```
Router# configure terminal
Router(config)# spanning-tree vlan 10 root primary diameter 4
Router(config)# exit
Router#
```

MAC Table Manipulation: Example

The following example shows a static entry being configured in the MAC address table:

```
Router(config)# mac-address-table static beef.beef.beef int fa0/1/5
Router(config)# end
```

The following example shows port security being configured in the MAC address table.

```
Router(config)# mac-address-table secure 0000.1111.2222 fa0/1/2 vlan 3
Router(config)# end
```

Switched Port Analyzer (SPAN) Source: Examples

- SPAN Source Configuration: Example, page 110
- SPAN Destination Configuration: Example, page 110
- Removing Sources or Destinations from a SPAN Session: Example, page 110

SPAN Source Configuration: Example

The following example shows SPAN session 1 being configured to monitor bidirectional traffic from source interface Fast Ethernet 0/1/1:

```
Router(config)# monitor session 1 source interface fastethernet 0/1/1
```

SPAN Destination Configuration: Example

The following example shows interface Fast Ethernet 0/3/7 being configured as the destination for SPAN session 1:

```
Router(config)# monitor session 1 destination interface fastethernet 0/3/7
```

Removing Sources or Destinations from a SPAN Session: Example

This following example shows interface Fast Ethernet 0/3/2 being removed as a SPAN source for SPAN session 1:

```
Router(config)# no monitor session 1 source interface fastethernet 0/3/2
```

IGMP Snooping: Example

The following example shows the output from configuring IGMP snooping:

```
Router# show mac-address-table multicast igmp-snooping

HWIC Slot: 1
--------------
    MACADDR     VLANID     INTERFACES

0100.5e05.0505    1        Fa0/1/1
0100.5e06.0606    2

HWIC Slot: 3
--------------
    MACADDR     VLANID     INTERFACES

0100.5e05.0505    1        Fa0/3/4
0100.5e06.0606    2        Fa0/3/0

Router#
```

The following is an example of output from the **show running interface** privileged EXEC command for VLAN 1:

```
Router# show running interface vlan 1

Building configuration...

Current configuration :82 bytes
!
interface Vlan1
 ip address 192.168.4.90 255.255.255.0
 ip pim sparse-mode
end

Router# show running interface vlan 2

Building configuration...

Current configuration :82 bytes
!
interface Vlan2
 ip address 192.168.5.90 255.255.255.0
 ip pim sparse-mode
end

Router#
Router# show ip igmp group

IGMP Connected Group Membership
Group Address    Interface                Uptime    Expires   Last Reporter
209.165.200.225 Vlan1                    01:06:40  00:02:20  192.168.41.101
209.165.200.226 Vlan2                    01:07:50  00:02:17  192.168.5.90
209.165.200.227 Vlan1                    01:06:37  00:02:25  192.168.41.100
209.165.200.228 Vlan2                    01:07:40  00:02:21  192.168.31.100
209.165.200.229 Vlan1                    01:06:36  00:02:22  192.168.41.101
209.165.200.230 Vlan2                    01:06:39  00:02:20  192.168.31.101
Router#

Router# show ip mroute

IP Multicast Routing Table
Flags:D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C -
Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
```

```
       U - URD, I - Received Source Specific Host Report
Outgoing interface flags:H - Hardware switched
Timers:Uptime/Expires
Interface state:Interface, Next-Hop or VCD, State/Mode

(*, 209.165.200.230), 01:06:43/00:02:17, RP 0.0.0.0, flags:DC
  Incoming interface:Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Vlan1, Forward/Sparse, 01:06:43/00:02:17

(*, 209.165.200.226), 01:12:42/00:00:00, RP 0.0.0.0, flags:DCL
  Incoming interface:Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Vlan2, Forward/Sparse, 01:07:53/00:02:14

(*, 209.165.200.227), 01:07:43/00:02:22, RP 0.0.0.0, flags:DC
  Incoming interface:Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Vlan1, Forward/Sparse, 01:06:40/00:02:22
    Vlan2, Forward/Sparse, 01:07:44/00:02:17

(*, 209.165.200.2282), 01:06:43/00:02:18, RP 0.0.0.0, flags:DC

  Incoming interface:Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Vlan1, Forward/Sparse, 01:06:40/00:02:18
    Vlan2, Forward/Sparse, 01:06:43/00:02:16

Router#
```

Storm-Control: Example

The following example shows bandwidth-based multicast suppression being enabled at 70 percent on Fast Ethernet interface 2:

```
Router# configure terminal
Router(config)# interface FastEthernet0/3/3
Router(config-if)# storm-control multicast threshold 70.0 30.0
Router(config-if)# end

Router# show storm-control multicast
Interface  Filter State  Upper    Lower    Current
---------  ------------  -----    -----    -------
Fa0/1/0    inactive      100.00%  100.00%  N/A
Fa0/1/1    inactive      100.00%  100.00%  N/A
Fa0/1/2    inactive      100.00%  100.00%  N/A
Fa0/1/3    inactive      100.00%  100.00%  N/A
Fa0/3/0    inactive      100.00%  100.00%  N/A
Fa0/3/1    inactive      100.00%  100.00%  N/A
Fa0/3/2    inactive      100.00%  100.00%  N/A
Fa0/3/3    Forwarding     70.00%   30.00%  0.00%
Fa0/3/4    inactive      100.00%  100.00%  N/A
Fa0/3/5    inactive      100.00%  100.00%  N/A
Fa0/3/6    inactive      100.00%  100.00%  N/A
Fa0/3/7    inactive      100.00%  100.00%  N/A
Fa0/3/8    inactive      100.00%  100.00%  N/A
```

Ethernet Switching: Examples

- Subnets for Voice and Data: Example, page 113

- Inter-VLAN Routing: Example, page 113
- Single Subnet Configuration: Example, page 114
- Ethernet Ports on IP Phones with Multiple Ports: Example, page 114

Subnets for Voice and Data: Example

The following example shows separate subnets being configured for voice and data on the EtherSwitch HWIC:

```
interface FastEthernet0/1/1
 description DOT1Q port to IP Phone
 switchport native vlan 50
 switchport mode trunk
 switchport voice vlan 150
```

interface Vlan 150

```
    description voice vlan
ip address 209.165.200.227 255.255.255.0
ip helper-address 209.165.200.228 (See Note below)

interface Vlan 50
    description data vlan
ip address 209.165.200.220 255.255.255.0
```

This configuration instructs the IP phone to generate a packet with an 802.1Q VLAN ID of 150 with an 802.1p value of 5 (default for voice bearer traffic).

Note In a centralized CallManager deployment model, the DHCP server might be located across the WAN link. If so, an **ip helper-address** command pointing to the DHCP server should be included on the voice VLAN interface for the IP phone. This is done to obtain its IP address as well as the address of the TFTP server required for its configuration.

Be aware that IOS supports a DHCP server function. If this function is used, the EtherSwitch HWIC serves as a local DHCP server and a helper address would not be required.

Inter-VLAN Routing: Example

Configuring inter-VLAN routing is identical to the configuration on an EtherSwitch HWIC with an MSFC. Configuring an interface for WAN routing is consistent with other IOS platforms.

The following example provides a sample configuration:

```
interface Vlan 160
 description voice vlan
 ip address 10.6.1.1 255.255.255.0

interface Vlan 60
 description data vlan
 ip address 10.60.1.1 255.255.255.0

interface Serial0/3/0
 ip address 172.3.1.2 255.255.255.0
```

Note Standard IGP routing protocols such as RIP, IGRP, EIGRP, and OSPF are supported on the EtherSwitch HWIC. Multicast routing is also supported for PIM dense mode, sparse mode and sparse-dense mode.

Single Subnet Configuration: Example

The EtherSwitch HWIC supports the use of an 802.1p-only option when configuring the voice VLAN. Using this option allows the IP phone to tag VoIP packets with a Cost of Service of 5 on the native VLAN, while all PC data traffic is sent untagged.

The following example shows a single subnet configuration for the EtherSwitch HWIC:

```
Router# FastEthernet 0/1/2
description Port to IP Phone in single subnet
 switchport access vlan 40
```

The EtherSwitch HWIC instructs the IP phone to generate an 802.1Q frame with a null VLAN ID value but with an 802.1p value (default is COS of 5 for bearer traffic). The voice and data VLANs are both 40 in this example.

Ethernet Ports on IP Phones with Multiple Ports: Example

The following example illustrates the configuration for the IP phone:

```
interface FastEthernet0/x/x
 switchport voice vlan x
 switchport mode trunk
```

The following example illustrates the configuration for the PC:

```
interface FastEthernet0/x/y
 switchport mode access
 switchport access vlan y
```

Note Using a separate subnet, and possibly a separate IP address space, may not be an option for some small branch offices due to the IP routing configuration. If the IP routing can handle an additional subnet at the remote branch, you can use Cisco Network Registrar and secondary addressing.

Additional References

The following sections provide references related to EtherSwitch HWICs.

Related Documents

Related Topic	Document Title
Hardware Installation of Interface Cards	*Cisco Interface Cards Installation Guide*
Information about configuring Voice over IP features	*Cisco IOS Voice, Video, and Fax Configuration Guide*
Voice over IP commands	*Cisco IOS Voice, Video, and Fax Command Reference, Release 12.3 T*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards have not been modified by this feature.	—

MIBs

MIBs	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs have not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFCs	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs have not been modified by this feature.	—

Technical Assistance

Description	Link
Technical Assistance Center (TAC) home page, containing 30,000 pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/public/support/tac/home.shtml

Feature Information for the Cisco HWIC-4ESW and the Cisco HWIC-D-9ESW EtherSwitch Cards

Table 3 lists the features in this module and provides links to specific configuration information. Only features that were introduced or modified in 12.3(8)T4 or a later release appear in the table.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Cisco IOS software images are specific to a Cisco IOS software release, a feature set, and a platform. Use Cisco Feature Navigator to find information about platform support and Cisco IOS software image support. Access Cisco Feature Navigator at http://www.cisco.com/go/fn. You must have an account on Cisco.com. If you do not have an account or have forgotten your username or password, click **Cancel** at the login dialog box and follow the instructions that appear.

Note Table 3 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 3 Feature Information for the 4-Port Cisco HWIC-4ESW and the 9-Port Cisco HWIC-D-9ESW EtherSwitch High Speed WAN Interface Cards

Feature Name	Releases	Feature Information
4-port Cisco HWIC-4ESW and the 9-port Cisco HWIC-D-9ESW EtherSwitch high speed WAN interface cards (HWICs) hardware feature	12.3(8)T4	The 4-port Cisco HWIC-4ESW and the 9-port Cisco HWIC-D-9ESW EtherSwitch high speed WAN interface cards (HWICs) hardware feature is supported on Cisco 1800 (modular), Cisco 2800, and Cisco 3800 series integrated services routers. Cisco EtherSwitch HWICs are 10/100BASE-T Layer 2 Ethernet switches with Layer 3 routing capability. (Layer 3 routing is forwarded to the host and is not actually performed at the switch.) Traffic between different VLANs on a switch is routed through the router platform. Any one port on a Cisco EtherSwitch HWIC may be configured as a stacking port to link to another Cisco EtherSwitch HWIC or EtherSwitch network module in the same system. An optional power module can also be added to provide inline power for IP telephones. The HWIC-D-9ESW HWIC requires a double-wide card slot.

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Multilayer Switching

Multilayer Switching Overview

This chapter provides an overview of Multilayer Switching (MLS).

Note The information in this chapter is a brief summary of the information contained in the *Catalyst 5000 Series Multilayer Switching User Guide*. The commands and configurations described in this guide apply only to the devices that provide routing services. Commands and configurations for Catalyst 5000 series switches are documented in the *Catalyst 5000 Series Multilayer Switching User Guide*.

MLS provides high-performance Layer 3 switching for Cisco routers and switches. MLS switches IP data packets between subnets using advanced application-specific integrated circuit (ASIC) switching hardware. Standard routing protocols, such as Open Shortest Path First (OSPF), Enhanced Interior Gateway Routing Protocol (Enhanced IGRP), Routing Information Protocol (RIP), and Intermediate System-to-Intermediate System (IS-IS), are used for route determination.

MLS enables hardware-based Layer 3 switching to offload routers from forwarding unicast IP data packets over shared media networking technologies such as Ethernet. The packet forwarding function is moved onto Layer 3 Cisco series switches whenever a partial or complete switched path exists between two hosts. Packets that do not have a partial or complete switched path to reach their destinations still use routers for forwarding packets.

MLS also provides traffic statistics as part of its switching function. These statistics are used for identifying traffic characteristics for administration, planning, and troubleshooting. MLS uses NetFlow Data Export (NDE) to export the flow statistics.

Procedures for configuring MLS and NDE on routers are provided in the "Configuring IP Multilayer Switching" chapter.

Procedures for configuring MLS and NDE on routers are provided in the following chapters in this publication:

- "Configuring IP Multilayer Switching" chapter
- "Configuring IP Multicast Multilayer Switching" chapter
- "Configuring IPX Multilayer Switching" chapter

This chapter describes MLS. It contains the following sections:

- Terminology
- Introduction to MLS

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- Key MLS Features
- MLS Implementation
- Standard and Extended Access Lists
- Introduction to IP Multicast MLS
- Introduction to IPX MLS
- Guidelines for External Routers
- Features That Affect MLS

Terminology

The following terminology is used in the MLS chapters:

- Multilayer Switching-Switching Engine (MLS-SE)—A NetFlow Feature Card (NFFC)-equipped Catalyst 5000 series switch.
- Multilayer Switching-Route Processor (MLS-RP)—A Cisco router with MLS enabled.
- Multilayer Switching Protocol (MLSP)—The protocol running between the MLS-SE and MLS-RP to enable MLS.

Introduction to MLS

Layer 3 protocols, such as IP and Internetwork Packet Exchange (IPX), are connectionless—they deliver each packet independently of each other. However, actual network traffic consists of many end-to-end conversations, or flows, between users or applications.

A flow is a unidirectional sequence of packets between a particular source and destination that share the same protocol and transport-layer information. Communication from a client to a server and from the server to the client is in separate flows. For example, HTTP Web packets from a particular source to a particular destination are in a separate flow from File Transfer Protocol (FTP) file transfer packets between the same pair of hosts.

Flows can be based on only Layer 3 addresses. This feature allows IP traffic from multiple users or applications to a particular destination to be carried on a single flow if only the destination IP address is used to identify a flow.

The NFFC maintains a Layer 3 switching table (MLS cache) for the Layer 3-switched flows. The cache also includes entries for traffic statistics that are updated in tandem with the switching of packets. After the MLS cache is created, packets identified as belonging to an existing flow can be Layer 3-switched based on the cached information. The MLS cache maintains flow information for all active flows. When the Layer 3-switching entry for a flow ages out, the flow statistics can be exported to a flow collector application.

For information on multicast MLS, see the "Introduction to IP Multicast MLS" section in this chapter.

Key MLS Features

Table 37 lists the key MLS features.

Table 37 Summary of Key Features

Feature	Description
Ease of Use	Is autoconfigurable and autonomously sets up its Layer 3 flow cache. Its "plug-and-play" design eliminates the need for you to learn new IP switching technologies.
Transparency	Requires no end-system changes and no renumbering of subnets. It works with DHCP[1] and requires no new routing protocols.
Standards Based	Uses IETF[2] standard routing protocols such as OSPF and RIP for route determination. You can deploy MLS in a multivendor network.
Investment Protection	Provides a simple feature-card upgrade on the Catalyst 5000 series switches. You can use MLS with your existing chassis and modules. MLS also allows you to use either an integrated RSM or an external router for route processing and Cisco IOS services.
Fast Convergence	Allows you to respond to route failures and routing topology changes by performing hardware-assisted invalidation of flow entries.
Resilience	Provides the benefits of HSRP[3] without additional configuration. This feature enables the switches to transparently switch over to the Hot Standby backup router when the primary router goes offline, eliminating a single point of failure in the network.
Access Lists	Allows you to set up access lists to filter, or to prevent traffic between members of different subnets. MLS enforces multiple security levels on every packet of the flow at wire speed. It allows you to configure and enforce access control rules on the RSM. Because MLS parses the packet up to the transport layer, it enables access lists to be validated. By providing multiple security levels, MLS enables you to set up rules and control traffic based on IP addresses and transport-layer application port numbers.
Accounting and Traffic Management	Allows you to see data flows as they are switched for troubleshooting, traffic management, and accounting purposes. MLS uses NDE to export the flow statistics. Data collection of flow statistics is maintained in hardware with no impact on switching performance. The records for expired and purged flows are grouped and exported to applications such as NetSys for network planning, RMON2[4] traffic management and monitoring, and accounting applications.
Network Design Simplification	Enables you to speed up your network while retaining the existing subnet structure. It makes the number of Layer 3 hops irrelevant in campus design, enabling you to cope with increases in any-to-any traffic.
Media Speed Access to Server Farms	You do not need to centralize servers in multiple VLANs to get direct connections. By providing security on a per-flow basis, you can control access to the servers and filter traffic based on subnet numbers and transport-layer application ports without compromising Layer 3 switching performance.
Faster Interworkgroup Connectivity	Addresses the need for higher-performance interworkgroup connectivity by intranet and multimedia applications. By deploying MLS, you gain the benefits of both switching and routing on the same platform.

1. DHCP = Dynamic Host Configuration Protocol
2. IETF = Internet Engineering Task Force
3. HSRP = Hot Standby Router Protocol
4. RMON2 = Remote Monitoring 2

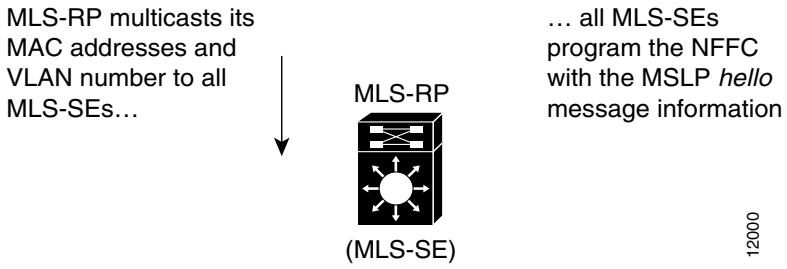
MLS Implementation

This section provides a step-by-step description of MLS implementation.

Note The MLS-RPs shown in the figures represent either a RSM or an externally attached Cisco router.

The MLSP informs the Catalyst 5000 series switch of the MLS-RP MAC addresses used on different VLANs and the MLS-RP's routing and access list changes. Through this protocol, the MLS-RP multicasts its MAC and VLAN information to all MLS-SEs. When the MLS-SE hears the MLSP *hello* message indicating an MLS initialization, the MLS-SE is programmed with the MLS-RP MAC address and its associated VLAN number (see Figure 63).

Figure 63 MLS Implementation

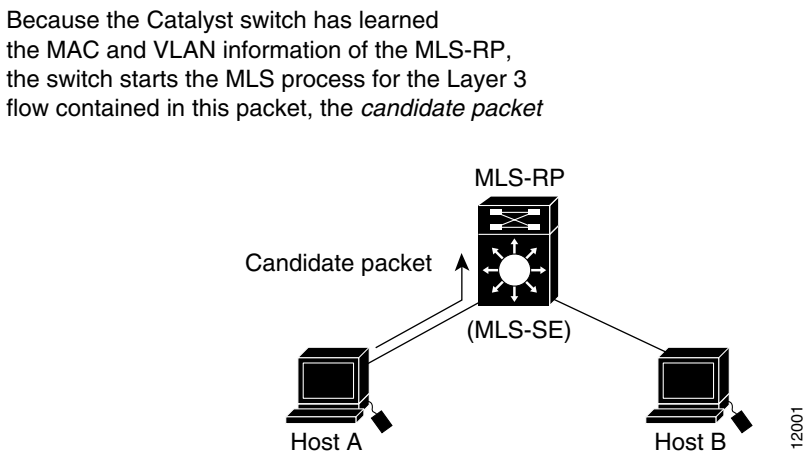

MLS-RP multicasts its MAC addresses and VLAN number to all MLS-SEs…
MLS-RP
(MLS-SE)
… all MLS-SEs program the NFFC with the MSLP *hello* message information
12000

In Figure 64, Host A and Host B are located on different VLANs. Host A initiates a data transfer to Host B. When Host A sends the first packet to the MLS-RP, the MLS-SE recognizes this packet as a *candidate packet* for Layer 3 switching because the MLS-SE has learned the MLS-RP's destination MAC address and VLAN through MLSP. The MLS-SE learns the Layer 3 flow information (such as the destination address, source address, and protocol port numbers), and forwards the first packet to the MLS-RP. A partial MLS entry for this Layer 3 flow is created in the MLS cache.

The MLS-RP receives the packet, looks at its route table to determine how to forward the packet, and applies services such as Access Control Lists (ACLs) and class of service (COS) policy.

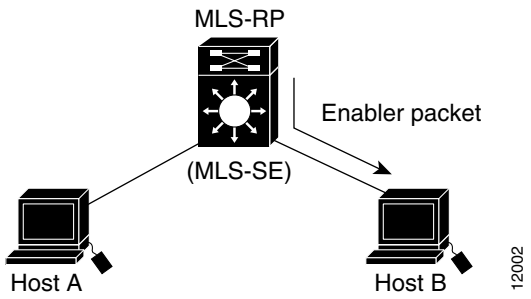
The MLS-RP rewrites the MAC header adding a new destination MAC address (Host B's) and its own MAC address as the source.

Figure 64 MLS Implementation


Because the Catalyst switch has learned the MAC and VLAN information of the MLS-RP, the switch starts the MLS process for the Layer 3 flow contained in this packet, the *candidate packet*
MLS-RP
Candidate packet
(MLS-SE)
Host A
Host B
12001

The MLS-RP routes the packet to Host B. When the packet appears back on the Catalyst 5000 series switch backplane, the MLS-SE recognizes the source MAC address as that of the MLS-RP, and that the packet's flow information matches the flow for which it set up a candidate entry. The MLS-SE considers this packet an *enabler packet* and completes the MLS entry (established by the candidate packet) in the MLS cache (see Figure 65).

Figure 65 MLS Implementation

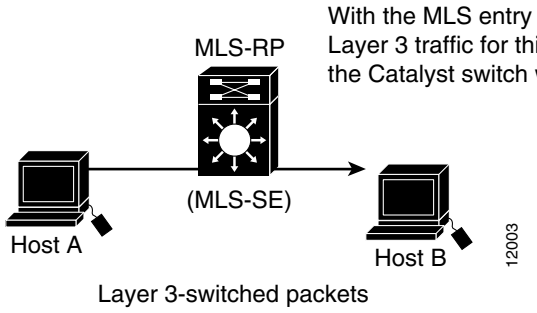

The MLS-RP routes this packet to Host B. Because the MLS-SE has learned both this MLS-RP and the Layer 3 flow in this packet, it completes the MLS entry in the MLS cache. The first routed packet is called the enabler packet
MLS-RP
Enabler packet
(MLS-SE)
Host A
Host B
12002

After the MLS entry has been completed, all Layer 3 packets with the same flow from Host A to Host B are Layer 3 switched directly inside the switch from Host A to Host B, bypassing the router (see Figure 66). After the Layer 3-switched path is established, the packet from Host A is rewritten by the MLS-SE before it is forwarded to Host B. The rewritten information includes the MAC addresses, encapsulations (when applicable), and some Layer 3 information.

The resultant packet format and protocol behavior is identical to that of a packet that is routed by the RSM or external Cisco router.

Note MLS is unidirectional. For Host B to communicate with Host A, another Layer 3-switched path needs to be created from Host B to Host A.

Figure 66 MLS Implementation


With the MLS entry from Host A to B established, the Layer 3 traffic for this flow is switched directly inside the Catalyst switch without going to the router
MLS-RP
(MLS-SE)
Host A
Host B
12003
Layer 3-switched packets

See the *Catalyst 5000 Series Multilayer Switching User Guide* for additional network implementation examples that include network topologies that do not support MLS.

Standard and Extended Access Lists

Note Router interfaces with input access lists *cannot* participate in MLS. However, any input access list can be translated to an output access list to provide the same effect on the interface. For complete details on how input and output access lists affect MLS, see the chapter "Configuring Multilayer Switching."

MLS allows you to enforce access lists on every packet of the flow without compromising MLS performance. When you enable MLS, standard and extended access lists are handled at wire speed by the MLS-SE. Access lists configured on the MLS-RP take effect automatically on the MLS-SE.

Additionally, route topology changes and the addition of access lists are reflected in the switching path of MLS.

Consider the case where an access list is configured on the MLS-RP to deny access from Station A to Station B. When Station A wants to communicate with Station B, it sends the first packet to the MLS-RP. The MLS-RP receives this packet and checks to learn if this packet flow is permitted. If an ACL is configured for this flow, the packet is discarded. Because the first packet for this flow does not return from the MLS-RP, an MLS cache entry is not established by the MLS-SE.

In another case, access lists are introduced on the MLS-RP while the flow is already being Layer 3 switched within the MLS-SE. The MLS-SE immediately enforces security for the affected flow by purging it.

Similarly, when the MLS-RP detects a routing topology change, the appropriate MLS cache entries are deleted in the MLS-SE. The techniques for handling route and access list changes apply to both the RSM and directly attached external routers.

Restrictions on Using IP Router Commands with MLS Enabled

The following Cisco IOS commands affect MLS on your router:

- **clear ip-route**—Clears all MLS cache entries for all Catalyst 5000 series switches performing Layer 3 switching for this MLS-RP.
- **ip routing**—The **no** form purges all MLS cache entries and disables MLS on this MLS-RP.
- **ip security** (all forms of this command)—Disables MLS on the interface.
- **ip tcp compression-connections**—Disables MLS on the interface.
- **ip tcp header-compression**—Disables MLS on the interface.

General Guidelines

The following is a list of general guidelines to enabling MLS:

- When you enable MLS, the RSM or externally attached router continues to handle all non-IP protocols while offloading the switching of IP packets to the MLS-SE.
- Do not confuse MLS with the NetFlow switching supported by Cisco routers. MLS uses both the RSM or directly attached external router and the MLS-SE. With MLS, you *are not* required to use NetFlow switching on the RSM or directly attached external router; any switching path on the RSM or directly attached external router will work (process, fast, and so on).

Introduction to IP Multicast MLS

The IP multicast MLS feature provides high-performance, hardware-based, Layer 3 switching of IP multicast traffic for routers connected to LAN switches.

An IP multicast flow is a unidirectional sequence of packets between a multicast source and the members of a destination multicast group. Flows are based on the IP address of the source device and the destination IP multicast group address.

IP multicast MLS switches IP multicast data packet flows between IP subnets using advanced, ASIC switching hardware, thereby off loading processor-intensive, multicast packet routing from network routers.

The packet forwarding function is moved onto the connected Layer 3 switch whenever a supported path exists between a source and members of a multicast group. Packets that do not have a supported path to reach their destinations are still forwarded in software by routers. Protocol Independent Multicast (PIM) is used for route determination.

IP Multicast MLS Network Topology

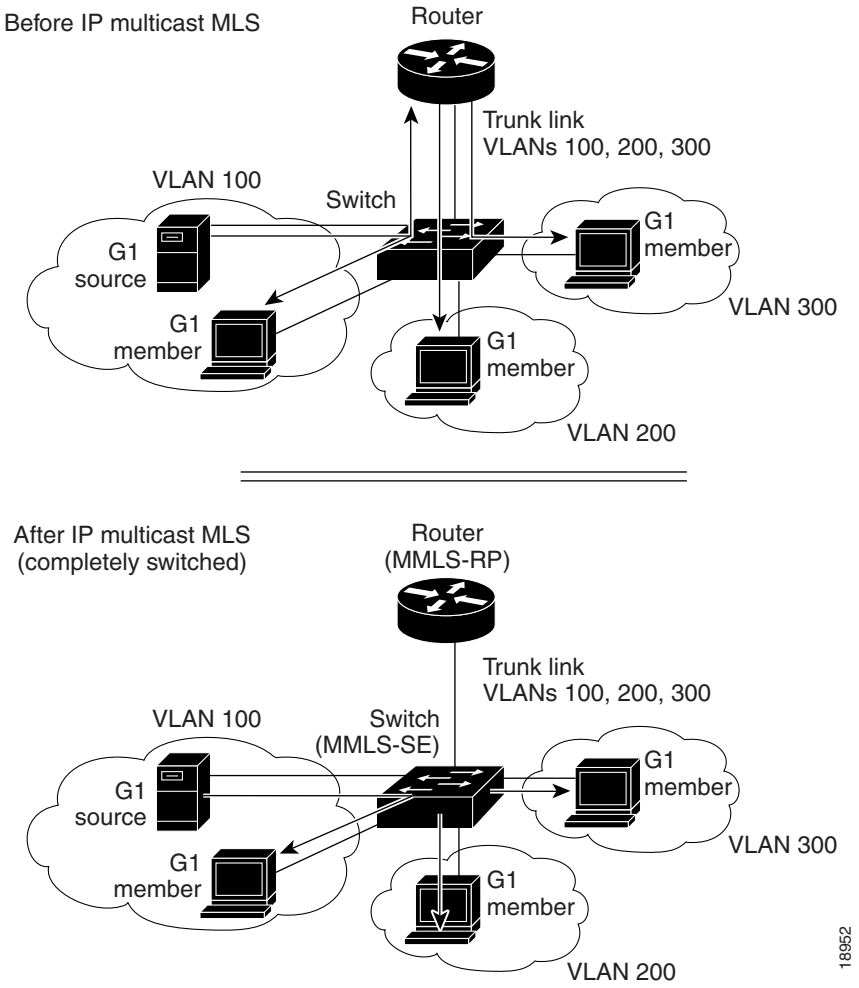
IP multicast MLS requires specific network topologies to function correctly. In each of these topologies, the source traffic is received on the switch, traverses a trunk link to the router, and returns to the switch over the same trunk link to reach the destination group members. The basic topology consists of a switch and an internal or external router connected through an ISL or 802.1Q trunk link.

Figure 67 shows this basic configuration before and after IP multicast MLS is deployed (assuming a completely switched flow). The topology consists of a switch, a directly connected external router, and multiple IP subnetworks (VLANs).

The network in the upper diagram in Figure 67 does not have the IP multicast MLS feature enabled. Note the arrows from the router to each multicast group in each VLAN. In this case, the router must replicate the multicast data packets to the multiple VLANs. The router can be easily overwhelmed with forwarding and replicated multicast traffic if the input rate or the number of outgoing interfaces increases.

As shown in the lower diagram in Figure 67, this potential problem is prevented by having the switch hardware forward the multicast data traffic. (Multicast control packets are still moving between the router and switch.)

Figure 67 Basic IP Multicast MLS Network Topology



Benefits of multicast MLS are as follows:

- Improves throughput—The improves throughput feature improves the router's multicast Layer 3 forwarding and replication throughput.
- Reduces load on router—If the router must replicate many multicast packets to many VLANs, it can be overwhelmed as the input rate and number of outgoing interfaces increase. Configuring the switch to replicate and forward the multicast flow reduces the demand on the router.
- Provides IP multicast scalability—If you need high throughput of multicast traffic, install a Catalyst 5000 series switch and configure the Provides IP Multicast Scalability feature. By reducing the load on your router, the router can accommodate more multicast flows.
- Provides meaningful flow statistics—IP multicast MLS provides flow statistics that can be used to administer, plan, and troubleshoot networks.

IP Multicast MLS Components

An IP multicast MLS network topology has two components:

- Multicast MLS-Switching Engine (MMLS-SE)—For example, a Catalyst 5000 series switch with hardware that supports IP multicast MLS. The MMLS-SE provides Layer 3 LAN-switching services.
- Multicast MLS-Route Processor (MMLS-RP)—Routing platform running Cisco IOS software that supports IP multicast MLS. The MMLS-RP interacts with the IP multicast routing software and updates the MLS cache in the MMLS-SE. When you enable IP multicast MLS, the MMLS-RP continues to handle all non-IP-multicast traffic while off loading IP multicast traffic forwarding to the MMLS-SE.

Layer 2 Multicast Forwarding Table

The MMLS-SE uses the Layer 2 multicast forwarding table to determine on which ports Layer 2 multicast traffic should be forwarded (if any). The Layer 2 multicast forwarding table is populated by enabling CGMP, IGMP snooping, or GMRP on the switch. These entries map the destination multicast MAC address to outgoing switch ports for a given VLAN.

Layer 3 Multicast MLS Cache

The MMLS-SE maintains the Layer 3 MLS cache to identify individual IP multicast flows. Each entry is of the form {source IP, destination group IP, source VLAN}. The maximum MLS cache size is 128K and is shared by all MLS processes on the switch (such as IP unicast MLS and IPX MLS). However, if the total of cache entries exceeds 32K, there is increased probability that a flow will not be switched by the MMLS-SE and will get forwarded to the router.

The MMLS-SE populates the MLS cache using information learned from the routers participating in IP multicast MLS. The router and switch exchange information using the multicast MLSP.

Whenever the router receives traffic for a new flow, it updates its multicast routing table and forwards the new information to the MMLS-SE using multicast MLSP. In addition, if an entry in the multicast routing table is aged out, the router deletes the entry and forwards the updated information to the MMLS-SE.

The MLS cache contains flow information for all active multilayer switched flows. After the MLS cache is populated, multicast packets identified as belonging to an existing flow can be Layer 3 switched based on the cache entry for that flow. For each cache entry, the MMLS-SE maintains a list of outgoing interfaces for the destination IP multicast group. The MMLS-SE uses this list to determine on which VLANs traffic to a given multicast flow should be replicated.

IP Multicast MLS Flow Mask

IP multicast MLS supports a single flow mask, source destination vlan. The MMLS-SE maintains one multicast MLS cache entry for each {source IP, destination group IP, source VLAN}. The multicast source destination vlan flow mask differs from the IP unicast MLS source destination ip flow mask in that, for IP multicast MLS, the source VLAN is included as part of the entry. The source VLAN is the multicast Reverse Path Forwarding (RPF) interface for the multicast flow.

Layer 3-Switched Multicast Packet Rewrite

When a multicast packet is Layer 3-switched from a multicast source to a destination multicast group, the MMLS-SE performs a packet rewrite based on information learned from the MMLS-RP and stored in the multicast MLS cache.

For example, if Server A sends a multicast packet addressed to IP multicast group G1 and members of group G1 are on VLANs other than the source VLAN, the MMLS-SE must perform a packet rewrite when it replicates the traffic to the other VLANs (the switch also bridges the packet in the source VLAN).

When the MMLS-SE receives the multicast packet, it is formatted similarly to the sample shown in Table 38.

Table 38 Layer 3-Switched Multicast Packet Header

Frame Header		**IP Header**				**Payload**	
Destination	Source	Destination	Source	TTL	Checksum	Data	Checksum
Group G1 MAC	*Server A MAC*	*Group G1 IP*	*Server A IP*	*n*	*calculation1*		

The MMLS-SE rewrites the packet as follows:

- Changes the source MAC address in the Layer 2 frame header from the MAC address of the server to the MAC address of the MMLS-RP (this MAC address is stored in the multicast MLS cache entry for the flow)
- Decrements the IP header Time to Live (TTL) by one and recalculates the IP header checksum

The result is a rewritten IP multicast packet that appears to have been routed by the router.
The MMLS-SE replicates the rewritten packet onto the appropriate destination VLANs, where it is forwarded to members of IP multicast group G1.

After the MMLS-SE performs the packet rewrite, the packet is formatted as shown in Table 39:

Table 39 Layer 3-Switched Multicast Packet Header with Rewrite

Frame Header		**IP Header**				**Payload**	
Destination	Source	Destination	Source	TTL	Checksum	Data	Checksum
Group G1 MAC	*MMLS-RP MAC*	*Group G1 IP*	*Server A IP*	*n – 1*	*calculation2*		

Partially and Completely Switched Flows

When at least one outgoing router interface for a given flow is multilayer switched, and at least one outgoing interface is not multilayer switched, that flow is considered partially switched. When a partially switched flow is created, all multicast traffic belonging to that flow still reaches the router and is software forwarded on those outgoing interfaces that are not multilayer switched.

A flow might be partially switched instead of completely switched in the following situations:

- Some multicast group destinations are located across the router (not all multicast traffic is received and sent on subinterfaces of the same trunk link).

- The router is configured as a member of the IP multicast group (using the **ip igmp join-group** interface command) on the RPF interface of the multicast source.
- The router is the first-hop router to the source in PIM sparse mode (in this case, the router must send PIM-register messages to the rendezvous point [RP]).
- Multicast TTL threshold or multicast boundary is configured on an outgoing interface for the flow.
- Multicast helper is configured on the RPF interface for the flow and multicast to broadcast translation is required.
- Access list restrictions are configured on an outgoing interface (see the "Access List Restrictions and Guidelines" section in the "Configuring Multicast Multilayer Switching" chapter).
- Integrated routing and bridging (IRB) is configured on the ingress interface.
- An output rate limit is configured on an outgoing interface.
- Multicast tag switching is configured on an outgoing interface.

When all the outgoing router interfaces for a given flow are multilayer switched, and none of the situations described applies to the flow, that flow is considered completely switched. When a completely switched flow is created, the MMLS-SE prevents multicast traffic bridged on the source VLAN for that flow from reaching the MMLS-RP interface in that VLAN, reducing the load on the router.

One consequence of a completely switched flow is that the router cannot record multicast statistics for that flow. Therefore, the MMLS-SE periodically sends multicast packet and byte count statistics for all completely switched flows to the router using multicast MLSP. The router updates the corresponding multicast routing table entry and resets the expiration timer for that multicast route.

Introduction to IPX MLS

The IPX MLS feature provides high-performance, hardware-based, Layer 3 switching for LAN switches. IPX data packet flows are switched between networks, off loading processor-intensive packet routing from network routers.

Whenever a partial or complete switched path exists between two hosts, packet forwarding occurs on Layer 3 switches. Packets without such a partial or complete switched path are still forwarded by routers to their destinations. Standard routing protocols such as RIP, Enhanced IGRP, and NetWare Link Services Protocol (NLSP) are used for route determination.

IPX MLS also allows you to debug and trace flows in your network. Use MLS explorer packets to identify which switch is handling a particular flow. These packets aid you in path detection and troubleshooting.

IPX MLS Components

An IPX MLS network topology has the following components:

- MLS-SE—For example, a Catalyst 5000 series switch with the Netflow Feature Card (NFFC II). The MLS-SE provides Layer 3 LAN-switching services.
- MLS-RP—For example, a Catalyst 5000 series RSM or an externally connected Cisco 4500, 4700, 7200, or 7500 series router with software that supports MLS. The MLS-RP provides Cisco IOS-based multiprotocol routing, network services, and central configuration and control for the switches.
- MLSP—The protocol running between the MLS-SE and MLS-RP that enables MLS.

IPX MLS Flows

Layer 3 protocols such as IP and IPX are connectionless—they deliver every packet independently of every other packet. However, actual network traffic consists of many end-to-end conversations, or flows, between users or applications.

A flow is a unidirectional packet sequence between a particular source and destination that share identical protocol and network-layer information. Communication flows from a client to a server and from the server to the client are distinct.

Flows are based only on Layer 3 addresses. If a destination IPX address identifies a flow, then IPX traffic from multiple users or applications to a particular destination can be carried on a single flow.

Layer 3-switched flows appear in the MLS cache, a special Layer 3 switching table is maintained by the NFFC II. The cache contains traffic statistics entries that are updated in tandem with packet switching. After the MLS cache is created, packets identified as belonging to an existing flow can be Layer 3 switched. The MLS cache maintains flow information for all active flows.

MLS Cache

The MLS-SE maintains a cache for IPX MLS flows and maintains statistics for each flow. An IPX MLS cache entry is created for the initial packet of each flow. Upon receipt of a packet that does not match any flow in the MLS cache, a new IPX MLS entry is created.

The state and identity of the flow are maintained while packet traffic is active; when traffic for a flow ceases, the entry ages out. You can configure the aging time for IPX MLS entries kept in the MLS cache. If an entry is not used for the specified period of time, the entry ages out and statistics for that flow can be exported to a flow collector application.

The maximum MLS cache size is 128,000 entries. However, an MLS cache larger than 32,000 entries increases the probability that a flow will not be switched by the MLS-SE and will get forwarded to the router.

Note The number of active flows that can be switched using the MLS cache depends on the type of access lists configured on MLS router interfaces (which determines the flow mask). See the “Flow Mask Modes” section later in this document.

Flow Mask Modes

Two flow mask modes—destination mode and destination-source mode—determine how IPX MLS entries are created for the MLS-SE.

You determine the mode when you configure IPX access lists on the MLS-RP router interfaces. Each MLS-RP sends MLSP messages about its flow mask to the MLS-SE, which performs Layer 3 switching. The MLS-SE supports only the most specific flow mask for its MLS-RPs. If it detects more than one mask, it changes to the most specific mask and purges the entire MLS cache. When an MLS-SE exports cached entries, it creates flow records from the most current flow mask mode. Depending on the current mode, some fields in the flow record might not have values. Unsupported fields are filled with a zero (0).

The two modes are described, as follows:

- Destination mode—The least-specific flow mask mode. The MLS-SE maintains one IPX MLS entry for each destination IPX address (network and node). All flows to a given destination IPX address use this IPX MLS entry. Use this mode if no access lists have been configured according to source IPX address on any of the IPX MLS router interfaces. In this mode the destination IPX address of the switched flows is displayed, along with the rewrite information: rewritten destination MAC, rewritten VLAN, and egress port.
- Destination-source mode—The MLS-SE maintains one MLS entry for each destination (network and node) and source (network only) IPX address pair. All flows between a given source and destination use this MLS entry regardless of the IPX sockets. Use this mode if an access list exists on any MLS-RP IPX interfaces that filter on source network.

Note The flow mask mode determines the display of the **show mls rp ipx** EXEC command. Refer to the *Cisco IOS Switching Services Command Reference* for details.

Layer 3-Switched Packet Rewrite

When a packet is Layer 3 switched from a source host to a destination host, the switch (MLS-SE) performs a packet rewrite based on information it learned from the router (MLS-RP) and then stored in the MLS cache.

If Host A and Host B are on different VLANs and Host A sends a packet to the MLS-RP to be routed to Host B, the MLS-SE recognizes that the packet was sent to the MAC address of the MLS-RP. The MLS-SE then checks the MLS cache and finds the entry matching the flow in question.

When the MLS-SE receives the packet, it is formatted as shown in Table 40:

Table 40 Layer 3-Switched Packet Header Sent to the MLS-RP

Frame Header		**Encap**	**IPX Header**				**Payload**	
Destination	Source	Length	Checksum/ IPX Length/ Transport Control[1]	Packet Type	Destination Net/Node/ Socket	Source Net/Node/ Socket	Data	PAD/FCS
MLS-RP MAC	*Host A MAC*				*Host B IPX*	*Host A IPX*		

1. Transport Control counts the number of times this packet has been routed. If this number is greater than the maximum (the default is 16), then the packet is dropped.

The MLS-SE rewrites the Layer 2 frame header, changing the destination MAC address to that of Host B and the source MAC address to that of the MLS-RP (these MAC addresses are stored in the IPX MLS cache entry for this flow). The Layer 3 IPX addresses remain the same. The MLS-SE rewrites the switched Layer 3 packets so that they appear to have been routed by a router.

The MLS-SE forwards the rewritten packet to Host B's VLAN (the destination VLAN is saved in the IPX MLS cache entry) and Host B receives the packet.

After the MLS-SE performs the packet rewrite, the packet is formatted as shown in Table 41:

Table 41 Layer 3-Switched Packet with Rewrite from the MLS-RP

Frame Header		Encap	IPX Header				Payload	
Destination	Source	Length	Checksum/ IPX Length/ Transport Control	Packet Type	Destination Net/Node/ Socket	Source Net/Node/ Socket	Data	PAD/FCS
Host B MAC	*MLS-RP MAC*				*Host B IPX*	*Host A IPX*		

IPX MLS Operation

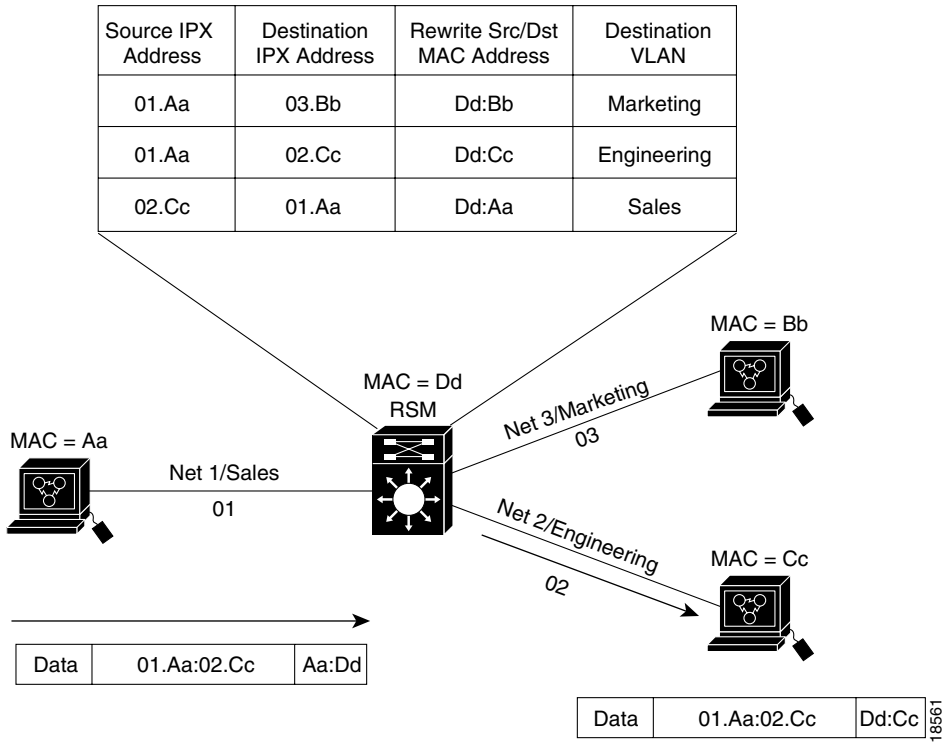
Figure 68 shows a simple IPX MLS network topology:

- Host A is on the Sales VLAN (IPX address 01.Aa).
- Host B is on the Marketing VLAN (IPX address 03.Bb).
- Host C is on the Engineering VLAN (IPX address 02.Cc).

When Host A initiates a file transfer to Host B, an IPX MLS entry for this flow is created (see the first item in Figure 68's table). When the MLS-RP forwards the first packet from Host A through the switch to Host B, the MLS-SE stores the MAC addresses of the MLS-RP and Host B in the IPX MLS entry. The MLS-SE uses this information to rewrite subsequent packets from Host A to Host B.

Similarly, a separate IPX MLS entry is created in the MLS cache for the traffic from Host A to Host C, and for the traffic from Host C to Host A. The destination VLAN is stored as part of each IPX MLS entry so that the correct VLAN identifier is used for encapsulating traffic on trunk links.

Figure 68 IPX MLS Example Topology



Standard Access Lists

Note Router interfaces with input access lists or outbound access lists unsupported by MLS cannot participate in IPX MLS. However, you can translate any input access list to an output access list to provide the same effect on the interface.

IPX MLS enforces access lists on every packet of the flow, without compromising IPX MLS performance. The MLS-SE handles permit traffic supported by MLS at wire speed.

Note Access list deny traffic is always handled by the MLS-RP, not the MLS-SE.

The MLS switching path automatically reflects route topology changes and the addition or modification of access lists on the MLS-SE. The techniques for handling route and access list changes apply to both the RSM and directly attached external routers.

For example, for Stations A and B to communicate, Station A sends the first packet to the MLS-RP. If the MLS-RP is configured with an access list to deny access from Station A to Station B, the MLS-RP receives the packet, checks its access list permissions to learn if the packet flow is permitted, and then discards the packet. Because the MLS-SE does not receive the returned first packet for this flow from the MLS-RP, the MLS-SE does not create an MLS cache entry.

In contrast, if the MLS-SE is already Layer 3 switching a flow and the access list is created on the MLS-RP, MLSP notifies the MLS-SE, and the MLS-SE immediately purges the affected flow from the MLS cache. New flows are created based on the restrictions imposed by the access list.

Similarly, when the MLS-RP detects a routing topology change, the MLS-SE deletes the appropriate MLS cache entries, and new flows are created based on the new topology.

Guidelines for External Routers

When using an external router, follow these guidelines:

- We recommend one directly attached external router per Catalyst 5000 series switch to ensure that the MLS-SE caches the appropriate flow information from both sides of the routed flow.
- You can use Cisco high-end routers (Cisco 7500, 7200, 4500, and 4700 series) for MLS when they are externally attached to the Catalyst 5000 series switch. You can make the attachment with multiple Ethernets (one per subnet), by using Fast Ethernet with the ISL, or with Fast Etherchannel.
- You can connect end hosts through any media (Ethernet, Fast Ethernet, ATM, and FDDI) but the connection between the external router and the Catalyst 5000 series switch must be through standard 10/100 Ethernet interfaces, ISL links, or Fast Etherchannel.

Features That Affect MLS

This section describes how certain features affect MLS.

Access Lists

The following sections describe how access lists affect MLS.

Input Access Lists

Router interfaces with input access lists *cannot* participate in MLS. If you configure an input access list on an interface, all packets for a flow that are destined for that interface go through the router (even if the flow is allowed by the router it is not Layer 3 switched). Existing flows for that interface get purged and no new flows are cached.

Note Any input access list can be translated to an output access list to provide the same effect on the interface.

Output Access Lists

If an output access list is applied to an interface, the MLS cache entries for that interface are purged. Entries associated with other interfaces are not affected; they follow their normal aging or purging procedures.

Applying an output access list to an interface, when the access list is configured using the **log**, **precedence**, **tos**, or **establish** keywords, prevents the interface from participating in MLS.

Access List Impact on Flow Masks

Access lists impact the flow mask advertised by an MLS-RP. When no access list on any MLS-RP interface, the flow mask mode is destination-ip (the least specific). When there is a standard access list is on any of the MLS-RP interfaces, the mode is source-destination-ip. When there is an extended access list is on any of the MLS-RP interfaces, the mode is ip-flow (the most specific).

Reflexive Access Lists

Router interfaces with reflexive access lists *cannot* participate in Layer 3 switching.

IP Accounting

Enabling IP accounting on an MLS-enabled interface disables the IP accounting functions on that interface.

Note To collect statistics for the Layer 3-switched traffic, enable NDE.

Data Encryption

MLS is disabled on an interface when the data encryption feature is configured on the interface.

Policy Route Maps

MLS is disabled on an interface when a policy route map is configured on the interface.

TCP Intercept

With MLS interfaces enabled, the TCP intercept feature (enabled in global configuration mode) might not work properly. When you enable the TCP intercept feature, the following message is displayed:

```
Command accepted, interfaces with mls might cause inconsistent behavior.
```

Network Address Translation

MLS is disabled on an interface when Network Address Translation (NAT) is configured on the interface.

Committed Access Rate

MLS is disabled on an interface when committed access rate (CAR) is configured on the interface.

Maximum Transmission Unit

The maximum transmission unit (MTU) for an MLS interface must be the default Ethernet MTU, 1500 bytes.

To change the MTU on an MLS-enabled interface, you must first disable MLS on the interface (enter **no mls rp ip** global configuration command in the interface). If you attempt to change the MTU with MLS enabled, the following message is displayed:

```
Need to turn off the mls router for this interface first.
```

If you attempt to enable MLS on an interface that has an MTU value other than the default value, the following message is displayed:

```
mls only supports interfaces with default mtu size
```

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Configuring IP Multilayer Switching

This chapter describes how to configure your network to perform IP Multilayer Switching (MLS). This chapter contains these sections:

- Configuring and Monitoring MLS
- Configuring NetFlow Data Export
- Multilayer Switching Configuration Examples

For a complete description of the commands in this chapter, refer to the the *Cisco IOS Switching Services Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the section "Identifying Supported Platforms" in the chapter "Using Cisco IOS Software."

Note The information in this chapter is a brief summary of the information contained in the *Catalyst 5000 Series Multilayer Switching User Guide*. The commands and configurations described in this guide apply only to the devices that provide routing services. Commands and configurations for Catalyst 5000 series switches are documented in the *Catalyst 5000 Series Multilayer Switching User Guide*. For configuration information for the Catalyst 6000 series switch, see *Configuring and Troubleshooting IP MLS on Catalyst 6000 with an MSFC* or the "Configuring IP Multilayer Switching" chapter in the *Catalyst 6500 Series MSFC (12.x) & PFC Configuration Guide*.

Configuring and Monitoring MLS

To configure your Cisco router for MLS, perform the tasks described in the following sections. The first section contains a required task; the remaining tasks are optional. To ensure a successful MLS configuration, you must also configure the Catalyst switches in your network. For a full description for the Catalyst 5000 series, see the *Catalyst 5000 Series Multilayer Switching User Guide*. For a full description for the Catalyst 6000 series, see the "Configuring IP Multilayer Switching" chapter in the *Catalyst 6500 Series MSFC (12.x) & PFC Configuration Guide*. Only configuration tasks and commands for routers are described in this chapter.

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- Configuring MLS on a Router (Required)
- Monitoring MLS (Optional)
- Monitoring MLS for an Interface (Optional)
- Monitoring MLS Interfaces for VTP Domains (Optional)

Configuring MLS on a Router

To configure MLS on your router, use the following commands beginning in global configuration mode. Depending upon your configuration, you might not have to perform all the steps in the procedure.

	Command	Purpose
Step 1	`Router(config)# mls rp ip`	Globally enables MLSP. MLSP is the protocol that runs between the MLS-SE and the MLS-RP.
Step 2	`Router(config)# interface type number`	Selects a router interface.
Step 3	`Router(config-if)# mls rp vtp-domain [domain-name]`	Selects the router interface to be Layer 3 switched and then adds that interface to the same VLAN Trunking Protocol (VTP) domain as the switch. This interface is referred to as the MLS interface. This command is required only if the Catalyst switch is in a VTP domain.
Step 4	`Router(config-if)# mls rp vlan-id [vlan-id-num]`	Assigns a VLAN ID to the MLS interface. MLS requires that each interface has a VLAN ID. This step is not required for RSM VLAN interfaces or ISL-encapsulated interfaces.
Step 5	`Router(config-if)# mls rp ip`	Enables each MLS interface.
Step 6	`Router(config-if)# mls rp management-interface`	Selects one MLS interface as a management interface. MLSP packets are sent and received through this interface. This can be any MLS interface connected to the switch.
	Repeat steps 2 through 5 for each interface that will support MLS.	

Note The interface-specific commands in this section apply only to Ethernet, Fast Ethernet, VLAN, and Fast Etherchannel interfaces on the Catalyst RSM/Versatile Interface Processor 2 (VIP2) or directly attached external router.

To globally disable MLS on the router, use the following command in global configuration mode:

Command	Purpose
`Router(config)# no mls rp ip`	Disables MLS on the router.

Monitoring MLS

To display MLS details including specifics for MLSP, use the following commands in EXEC mode, as needed:

- MLS status (enabled or disabled) for switch interfaces and subinterfaces
- Flow mask used by this MLS-enabled switch when creating Layer 3-switching entries for the router
- Current settings of the keepalive timer, retry timer, and retry count
- MLSP-ID used in MLSP messages
- List of interfaces in all VTP domains that are enabled for MLS

Command	Purpose
Router# **show mls rp**	Displays MLS details for all interfaces.

After entering this command, you see this display:

```
router# show mls rp

multilayer switching is globally enabled
mls id is 00e0.fefc.6000
mls ip address 10.20.26.64
mls flow mask is ip-flow

vlan domain name: WBU
   current flow mask: ip-flow
   current sequence number: 80709115
   current/maximum retry count: 0/10
   current domain state: no-change
   current/next global purge: false/false
   current/next purge count: 0/0
   domain uptime: 13:03:19
   keepalive timer expires in 9 seconds
   retry timer not running
   change timer not running
   fcp subblock count = 7

   1 management interface(s) currently defined:
      vlan 1 on Vlan1

   7 mac-vlan(s) configured for multi-layer switching:

      mac 00e0.fefc.6000
         vlan id(s)
         1    10   91   92   93   95   100

   router currently aware of following 1 switch(es):
      switch id 0010.1192.b5ff
```

Monitoring MLS for an Interface

To show MLS information for a specific interface, use the following command in EXEC mode:

Command	Purpose
Router# **show mls rp** [*interface*]	Displays MLS details for a specific interface.

After entering this command, you see this display:

```
router# show mls rp int vlan 10
```

```
mls active on Vlan10, domain WBU
router#
```

Monitoring MLS Interfaces for VTP Domains

To show MLS information for a specific VTP domain use the following command in EXEC mode:

Command	Purpose
Router# **show mls rp vtp-domain** [*domain-name*]	Displays MLS interfaces for a specific VTP domain.

After entering this command, you see this display:

```
router# show mls rp vtp-domain WBU

vlan domain name: WBU
   current flow mask: ip-flow
   current sequence number: 80709115
   current/maximum retry count: 0/10
   current domain state: no-change
   current/next global purge: false/false
   current/next purge count: 0/0
   domain uptime: 13:07:36
   keepalive timer expires in 8 seconds
   retry timer not running
   change timer not running
   fcp subblock count = 7

   1 management interface(s) currently defined:
      vlan 1 on Vlan1

   7 mac-vlan(s) configured for multi-layer switching:

      mac 00e0.fefc.6000
         vlan id(s)
         1    10   91   92   93   95   100

   router currently aware of following 1 switch(es):
      switch id 0010.1192.b5ff
```

Configuring NetFlow Data Export

Note You need to enable NDE *only* if you will export MLS cache entries to a data collection application.

Perform the task in this section to configure your Cisco router for NDE. To ensure a successful NDE configuration, you must also configure the Catalyst switch. For a full description, see the *Catalyst 5000 Series Multilayer Switching User Guide*.

Specifying an NDE Address on the Router

To specify an NDE address on the router, use the following command in global configuration mode:

Command	Purpose
`Router(config)# mls rp nde-address ip-address`	Specifies an NDE IP address for the router doing the Layer 3 switching. The router and the Catalyst 5000 series switch use the NDE IP address when sending MLS statistics to a data collection application.

Multilayer Switching Configuration Examples

In these examples, VLAN interfaces 1 and 3 are in VTP domain named Engineering. The management interface is configured on the VLAN 1 interface. Only information relevant to MLS is shown in the following configurations:

- Router Configuration Without Access Lists Example
- Router Configuration with a Standard Access List Example
- Router Configuration with an Extended Access List Example

Router Configuration Without Access Lists Example

This sample configuration shows a router configured without access lists on any of the VLAN interfaces. The flow mask is configured to be destination-ip.

```
router#more system:running-config

Building configuration...

Current configuration:
.
.
.
mls rp ip

interface Vlan1
 ip address 172.20.26.56 255.255.255.0
 mls rp vtp-domain Engineering
 mls rp management-interface
 mls rp ip

interface Vlan2
 ip address 172.16.2.73 255.255.255.0

interface Vlan3
 ip address 172.16.3.73 255.255.255.0
 mls rp vtp-domain Engineering
 mls rp ip
 .
 .
 end
router#
router#show mls rp

multilayer switching is globally enabled
mls id is 0006.7c71.8600
mls ip address 172.20.26.56
mls flow mask is destination-ip
```

```
number of domains configured for mls 1
vlan domain name: Engineering
   current flow mask: destination-ip
   current sequence number: 82078006
   current/maximum retry count: 0/10
   current domain state: no-change
   current/next global purge: false/false
   current/next purge count: 0/0
   domain uptime: 02:54:21
   keepalive timer expires in 11 seconds
   retry timer not running
   change timer not running

   1 management interface(s) currently defined:
      vlan 1 on Vlan1

   2 mac-vlan(s) configured for multi-layer switching:

      mac 0006.7c71.8600
         vlan id(s)
         1    3

   router currently aware of following 1 switch(es):
      switch id 00e0.fe4a.aeff
```

Router Configuration with a Standard Access List Example

This configuration is the same as the previous example but with a standard access list configured on the VLAN 3 interface. The flow mask changes to source-destination-ip.

```
.
interface Vlan3
 ip address 172.16.3.73 255.255.255.0
 ip access-group 2 out
 mls rp vtp-domain Engineering
 mls rp ip
.

router# show mls rp

multilayer switching is globally enabled
mls id is 0006.7c71.8600
mls ip address 172.20.26.56
mls flow mask is source-destination-ip

number of domains configured for mls 1
vlan domain name: Engineering
   current flow mask: source-destination-ip
   current sequence number: 82078007
   current/maximum retry count: 0/10
   current domain state: no-change
   current/next global purge: false/false
   current/next purge count: 0/0
   domain uptime: 02:57:31
   keepalive timer expires in 4 seconds
   retry timer not running
   change timer not running

   1 management interface(s) currently defined:
      vlan 1 on Vlan1
```

```
   2 mac-vlan(s) configured for multi-layer switching:

      mac 0006.7c71.8600
         vlan id(s)
         1    3

   router currently aware of following 1 switch(es):
      switch id 00e0.fe4a.aeff
```

Router Configuration with an Extended Access List Example

This configuration is the same as the previous examples but with an extended access list configured on the VLAN 3 interface. The flow mask changes to ip-flow.

```
.
interface Vlan3
 ip address 172.16.3.73 255.255.255.0
 ip access-group 101 out
 mls rp vtp-domain Engineering
 mls rp ip
.


router# show mls rp

multilayer switching is globally enabled
mls id is 0006.7c71.8600
mls ip address 172.20.26.56
mls flow mask is ip-flow

number of domains configured for mls 1
vlan domain name: Engineering
   current flow mask: ip-flow
   current sequence number: 82078009
   current/maximum retry count: 0/10
   current domain state: no-change
   current/next global purge: false/false
   current/next purge count: 0/0
   domain uptime: 03:01:52
   keepalive timer expires in 3 seconds
   retry timer not running
   change timer not running

   1 management interface(s) currently defined:
      vlan 1 on Vlan1

   2 mac-vlan(s) configured for multi-layer switching:

      mac 0006.7c71.8600
         vlan id(s)
         1    3

   router currently aware of following 1 switch(es):
      switch id 00e0.fe4a.aeff
```

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Configuring IP Multicast Multilayer Switching

This chapter describes how to configure your network to perform IP multicast Multilayer Switching (MLS). This chapter contains these sections:

- Prerequisites
- Restrictions
- Configuring and Monitoring IP Multicast MLS
- IP Multicast MLS Configuration Examples

For a complete description of the commands in this chapter, refer to the the *Cisco IOS Switching Services Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the section "Identifying Supported Platforms" in the chapter "Using Cisco IOS Software."

Note The information in this chapter is a brief summary of the information contained in the *Catalyst 5000 Series Multilayer Switching User Guide*. The commands and configurations described in this guide apply only to the devices that provide routing services. Commands and configurations for Catalyst 5000 series switches are documented in the *Catalyst 5000 Series Multilayer Switching User Guide*.

Prerequisites

The following prerequisites are necessary before MLS can function:

- A VLAN interface must be configured on both the switch and the router. For information on configuring inter-VLAN routing on the RSM or an external router, refer to the *Catalyst 5000 Software Configuration Guide*.
- IP multicast MLS must be configured on the switch. For procedures on this task, refer to the "Configuring IP Multicast Routing" chapter in the *Cisco IOS IP Routing Configuration Guide*.

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- IP multicast routing and PIM must be enabled on the router. The minimal steps to configure them are described in the "Configuring and Monitoring IP Multicast MLS" section later in this document. For detailed information on configuring IP multicast routing and PIM, refer to the *Cisco IOS IP Routing Configuration Guide*.

Restrictions

You must also configure the Catalyst 5000 series switch in order for IP multicast MLS to function on the router.

The restrictions in the following sections apply to IP multicast MLS on the router:

- Router Configuration Restrictions
- External Router Guidelines
- Access List Restrictions and Guidelines

Router Configuration Restrictions

IP multicast MLS does not work on internal or external routers in the following situations:

- If IP multicast MLS is disabled on the RPF interface for the flow (using the **no mls rp ip multicast** interface configuration command).
- For IP multicast groups that fall into these ranges (where * is in the range from 0 to 255):
  - 224.0.0.* through 239.0.0.*
  - 224.128.0.* through 239.128.0.*

Note Groups in the 224.0.0.* range are reserved for routing control packets and must be flooded to all forwarding ports of the VLAN. These addresses map to the multicast MAC address range 01-00-5E-00-00-*xx,* where *xx* is in the range from 0 to 0xFF.

- For PIM auto-RP multicast groups (IP multicast group addresses 224.0.1.39 and 224.0.1.40).
- For flows that are forwarded on the multicast shared tree (that is, {*, G, *} forwarding) when the interface or group is running PIM sparse mode.
- If the shortest path tree (SPT) bit for the flow is cleared when running PIM sparse mode for the interface or group.
- When an input rate limit is applied on an RPF interface.
- For any RPF interface with access lists applied (for detailed information, see the "Access List Restrictions and Guidelines" section later in this document).
- For any RPF interface with multicast boundary configured.
- For packets that require fragmentation and packets with IP options. However, packets in the flow that are not fragmented or that do not specify IP options are multilayer switched.
- On external routers, for source traffic received at the router on non-ISL or non-802.1Q interfaces.
- For source traffic received on tunnel interfaces (such as MBONE traffic).
- For any RPF interface with multicast tag switching enabled.

External Router Guidelines

Follow these guidelines when using an external router:

- The connection to the external router must be over a single ISL or 802.1Q trunk link with subinterfaces (using appropriate encapsulation type) configured.
- A single external router can serve as the MMLS-RP for multiple switches, provided each switch connects to the router through a separate ISL or 802.1Q trunk link.
- If the switch connects to a single router through multiple trunk links, IP multicast MLS is supported on one of the links only. You must disable IP multicast MLS on the redundant links using the **no mls rp ip multicast** interface configuration command.
- You can connect end hosts (source or multicast destination devices) through any media (Ethernet, Fast Ethernet, ATM, and FDDI), but the connection between external routers and the switch must be through Fast Ethernet or Gigabit Ethernet interfaces.

Access List Restrictions and Guidelines

The following restrictions apply when using access lists on interfaces participating in IP multicast MLS:

- All standard access lists are supported on any interface. The flow is multilayer switched on all interfaces on which the traffic for the flow is allowed by the access list.
- Layer 4 port-based extended IP input access lists are not supported. For interfaces with these access lists applied, no flows are multilayer switched.
- Extended access lists on the RPF interface that specify conditions other than Layer 3 source, Layer 3 destination, and **ip** protocol are not multilayer switched.

  For example, if the following input access list is applied to the RPF interface for a group of flows, no flows will be multilayer switched even though the second entry permits all IP traffic (because the protocol specified in the first entry is not **ip**):

```
Router(config)# access-list 101 permit udp any any
Router(config)# access-list 101 permit ip any any
```

  If the following input access list is applied to the RPF interface for a group of flows, all flows except the {s1, g1} flow are multilayer switched (because the protocol specified in the entry for {s1, g1} is not **ip**):

```
Router(config)# access-list 101 permit udp s1 g1
Router(config)# access-list 101 permit ip any any
```

Configuring and Monitoring IP Multicast MLS

To configure your Cisco router for IP multicast MLS, perform the tasks described in the following sections. The first two sections contain required tasks; the remaining tasks are optional. To ensure a successful multicast MLS configuration, you must also configure the Catalyst switches in your network. For a full description, refer to the *Catalyst 5000 Series Multilayer Switching User Guide*.

- Enabling IP Multicast Routing (Required)
- Enabling IP PIM (Required)
- Enabling IP Multicast MLS (Optional, this is a required task if you disabled it.)
- Specifying a Management Interface (Optional)

For examples of IP multicast MLS configurations, see the "IP Multicast MLS Configuration Examples" section later in this document.

Enabling IP Multicast Routing

You must enable IP multicast routing globally on the MMLS-RPs before you can enable IP multicast MLS on router interfaces. To enable IP multicast routing on the router, use the following command in router configuration mode:

Command	Purpose
`Router(config)# ip multicast-routing`	Enables IP multicast routing globally.

Note This section describes only how to enable IP multicast routing on the router. For detailed IP multicast configuration information, refer to the "Configuring IP Multicast Routing" chapter in the *Cisco IOS IP Routing Configuration Guide*.

Enabling IP PIM

You must enable PIM on the router interfaces connected to the switch before IP multicast MLS will function on those router interfaces. To do so, use the following commands beginning in interface configuration mode:

	Command	Purpose
Step 1	`Router(config)# interface type number`	Configures an interface.
Step 2	`Router(config-if)# ip pim {dense-mode | sparse-mode | sparse-dense-mode}`	Enables PIM on the interface.

Note This section describes only how to enable PIM on router interfaces. For detailed PIM configuration information, refer to the "Configuring IP Multicast Routing" chapter in the *Cisco IOS IP Routing Configuration Guide*.

Enabling IP Multicast MLS

IP multicast MLS is enabled by default when you enable PIM on the interface. Perform this task only if you disabled IP multicast MLS and you want to reenable it. To enable IP multicast MLS on an interface, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# mls rp ip multicast`	Enables IP multicast MLS on an interface.

Specifying a Management Interface

When you enable IP multicast MLS, the subinterface (or VLAN interface) that has the lowest VLAN ID and is active (in the "up" state) is automatically selected as the *management interface*. The one-hop protocol Multilayer Switching Protocol (MLSP) is used between a router and a switch to pass messages about hardware-switched flows. MLSP packets are sent and received on the management interface. Typically, the interface in VLAN 1 is chosen (if that interface exists). Only one management interface is allowed on a single trunk link.

In most cases, we recommend that the management interface be determined by default. However, you can optionally specify a different router interface or subinterface as the management interface. We recommend using a subinterface with minimal data traffic so that multicast MLSP packets can be sent and received more quickly.

If the user-configured management interface goes down, the router uses the default interface (the active interface with the lowest VLAN ID) until the user-configured interface comes up again.

To change the default IP multicast MLS management interface, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# mls rp ip multicast management-interface`	Configures an interface as the IP multicast MLS management interface.

Monitoring and Maintaining IP Multicast MLS

To monitor and maintain an IP multicast MLS network, use the following commands in EXEC modes, as needed:

Command	Purpose
`Router# show ip mroute [group-name | group-address [source]]`	Displays hardware switching state for outgoing interfaces.
`Router# show ip pim interface [type number] [count]`	Displays PIM interface information.
`Router# show mls rp ip multicast [locate] [group [source] [vlan-id]] | [statistics] | [summary]`	Displays Layer 3 switching information.

IP Multicast MLS Configuration Examples

The following sections contain example IP multicast MLS implementations. These examples include the switch configurations, although switch commands are not documented in this router publication. Refer to the *Catalyst 5000 Command Reference* for that information.

- Basic IP Multicast MLS Network Examples
- Complex IP Multicast MLS Network Examples

Basic IP Multicast MLS Network Examples

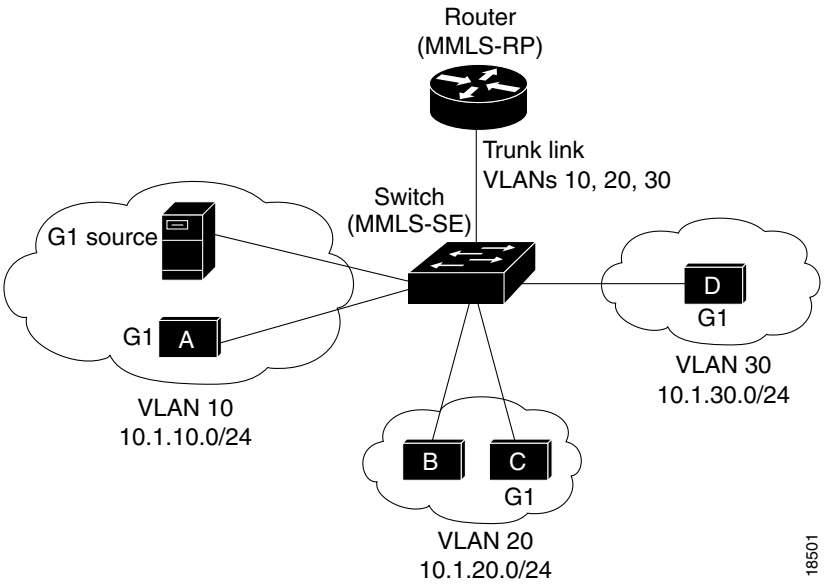
This example consists of the following sections:

- Network Topology Example
- Operation Before IP Multicast MLS Example
- Operation After IP Multicast MLS Example
- Router Configuration
- Switch Configuration

Network Topology Example

Figure 69 shows a basic IP multicast MLS example network topology.

Figure 69 Example Network: Basic IP Multicast MLS



The network is configured as follows:

- There are three VLANs (IP subnetworks): VLANs 10, 20, and 30.
- The multicast source for group G1 belongs to VLAN 10.
- Hosts A, C, and D have joined IP multicast group G1.
- Port 1/2 on the MMLS-SE is connected to interface fastethernet2/0 on the MMLS-RP.
- The link between the MMLS-SE and the MMLS-RP is configured as an ISL trunk.
- The subinterfaces on the router interface have these IP addresses:
  - fastethernet2/0.10: 10.1.10.1 255.255.255.0 (VLAN 10)
  - fastethernet2/0.20: 10.1.20.1 255.255.255.0 (VLAN 20)
  - fastethernet2/0.30: 10.1.30.1 255.255.255.0 (VLAN 30)

Operation Before IP Multicast MLS Example

Without IP multicast MLS, when the G1 source (on VLAN 10) sends traffic destined for IP multicast group G1, the switch forwards the traffic (based on the Layer 2 multicast forwarding table entry generated by the IGMP snooping, CGMP, or GMRP multicast service) to Host A on VLAN 10 and to the router subinterface in VLAN 10.

The router receives the multicast traffic on its incoming subinterface for VLAN 10, checks the multicast routing table, and replicates the traffic to the outgoing subinterfaces for VLANs 20 and 30. The switch receives the traffic on VLANs 20 and 30 and forwards the traffic received on these VLANs to the appropriate switch ports, again based on the contents of the Layer 2 multicast forwarding table.

Operation After IP Multicast MLS Example

After IP multicast MLS is implemented, when the G1 source sends traffic destined for multicast group G1, the MMLS-SE checks its Layer 3 multicast MLS cache and recognizes that the traffic belongs to a multicast MLS flow. The MMLS-SE forwards the traffic to Host A on VLAN 10 based on the multicast forwarding table, but does not forward the traffic to the router subinterface in VLAN 10 (assuming a completely switched flow).

For each multicast MLS cache entry, the switch maintains a list of outgoing interfaces for the destination IP multicast group. The switch replicates the traffic on the appropriate outgoing interfaces (VLANs 20 and 30) and then forwards the traffic on each VLAN to the destination hosts (using the Layer 2 multicast forwarding table). The switch performs a packet rewrite for the replicated traffic so that the packets appear to have been routed by the appropriate router subinterface.

If not all the router subinterfaces are eligible to participate in IP multicast MLS, the switch must forward the multicast traffic to the router subinterface in the source VLAN (in this case, VLAN 10). In this situation, on those subinterfaces that are ineligible, the router performs multicast forwarding and replication in software, in the usual manner. On those subinterfaces that are eligible, the switch performs multilayer switching.

Note On the MMLS-RP, the IP multicast MLS management interface is user-configured to the VLAN 30 subinterface. If this interface goes down, the system will revert to the default management interface (in this case, the VLAN 10 subinterface).

Router Configuration

The following is an example configuration of IP multicast MLS on the router:

```
ip multicast-routing
interface fastethernet2/0.10
 encapsulation isl 10
 ip address 10.1.10.1 255.255.255.0
 ip pim dense-mode
interface fastethernet2/0.20
 encapsulation isl 20
 ip address 10.1.20.1 255.255.255.0
 ip pim dense-mode
interface fastethernet2/0.30
 encapsulation isl 30
 ip address 10.1.30.1 255.255.255.0
 ip pim dense-mode
 mls rp ip multicast management-interface
```

You will receive the following message informing you that you changed the management interface:

```
Warning: MLS Multicast management interface is now Fa2/0.30
```

Switch Configuration

The following example shows how to configure the switch (MMLS-SE):

```
Console> (enable) set trunk 1/2 on isl
Port(s) 1/2 trunk mode set to on.
Port(s) 1/2 trunk type set to isl.
Console> (enable) set igmp enable
IGMP feature for IP multicast enabled
Console> (enable) set mls multicast enable
Multilayer Switching for Multicast is enabled for this device.
Console> (enable) set mls multicast include 10.1.10.1
Multilayer switching for multicast is enabled for router 10.1.10.1.
```

Complex IP Multicast MLS Network Examples

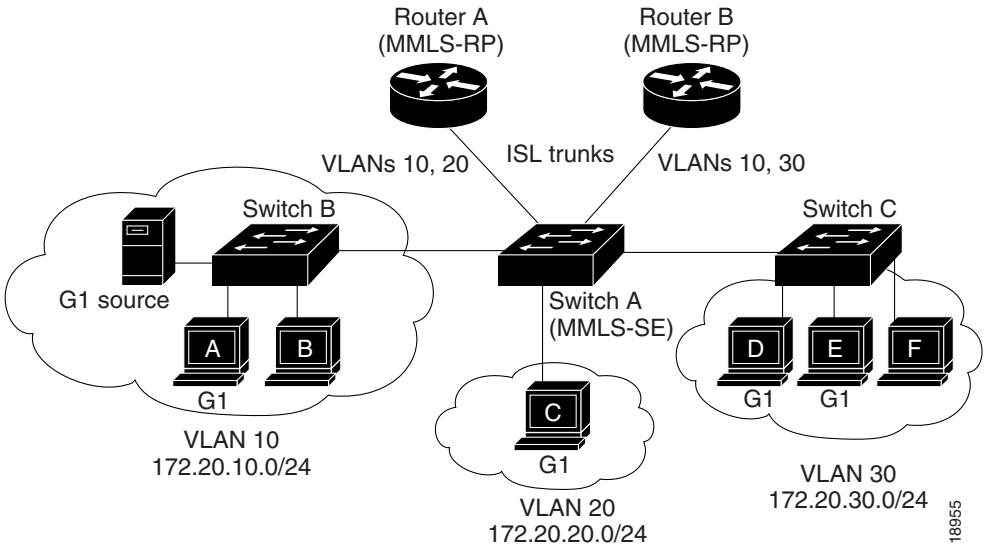
This example consists of the following sections:

- Network Topology Example
- Operation Before IP Multicast MLS Example
- Operation After IP Multicast MLS Example
- Router A (MMLS-RP) Configuration
- Router B (MMLS-RP) Configuration
- Switch A (MMLS-SE) Configuration
- Switch B Configuration
- Switch C Configuration

Network Topology Example

Figure 70 shows a more complex IP multicast MLS example network topology.

Figure 70 Complex IP Multicast MLS Example Network



The network is configured as follows:

- There are four VLANs (IP subnetworks): VLANs 1, 10, 20, and 30 (VLAN 1 is used only for management traffic, not multicast data traffic).
- The G1 multicast source belongs to VLAN 10.
- Hosts A, C, D, and E have joined IP multicast group G1.
- Switch A is the MMLS-SE.
- Router A and Router B are both operating as MMLS-RPs.
- Port 1/1 on the MMLS-SE is connected to interface fastethernet1/0 on Router A.
- Port 1/2 on the MMLS-SE is connected to interface fastethernet2/0 on Router B.
- The MMLS-SE is connected to the MMLS-RPs through ISL trunk links.
- The trunk link to Router A carries VLANs 1, 10, and 20.
- The trunk link to Router B carries VLANs 1, 10, and 30.
- The subinterfaces on the Router A interface have these IP addresses:
  - fastethernet1/0.1: 172.20.1.1 255.255.255.0 (VLAN 1)
  - fastethernet1/0.10: 172.20.10.1 255.255.255.0 (VLAN 10)
  - fastethernet1/0.20: 172.20.20.1 255.255.255.0 (VLAN 20)
- The subinterfaces on the Router B interface have these IP addresses:
  - fastethernet1/0.1: 172.20.1.2 255.255.255.0 (VLAN 1)
  - fastethernet2/0.10: 172.20.10.100 255.255.255.0 (VLAN 10)
  - fastethernet2/0.30: 172.20.30.100 255.255.255.0 (VLAN 30)
- The default IP multicast MLS management interface is used on both MMLS-RPs (VLAN 1).
- Port 1/3 on the MMLS-SE is connected to Switch B through an ISL trunk link carrying all VLANs.
- Port 1/4 on the MMLS-SE is connected to Switch C through an ISL trunk link carrying all VLANs.

- Switch B and Switch C perform Layer 2 switching functions only.

Operation Before IP Multicast MLS Example

Without IP multicast MLS, when Server A (on VLAN 10) sends traffic destined for IP multicast group G1, Switch B forwards the traffic (based on the Layer 2 multicast forwarding table entry) to Host A on VLAN 10 and to Switch A. Switch A forwards the traffic to the Router A and Router B subinterfaces in VLAN 10.

Router A receives the multicast traffic on its incoming subinterface for VLAN 10, checks the multicast routing table, and replicates the traffic to the outgoing subinterface for VLAN 20. Router B receives the multicast traffic on its incoming interface for VLAN 10, checks the multicast routing table, and replicates the traffic to the outgoing subinterface for VLAN 30.

Switch A receives the traffic on VLANs 20 and 30. Switch A forwards VLAN 20 traffic to the appropriate switch ports (in this case, to Host C), based on the contents of the Layer 2 multicast forwarding table. Switch A forwards the VLAN 30 traffic to Switch C.

Switch C receives the VLAN 30 traffic and forwards it to the appropriate switch ports (in this case, Hosts D and E) using the multicast forwarding table.

Operation After IP Multicast MLS Example

After IP multicast MLS is implemented, when Server A sends traffic destined for multicast group G1, Switch B forwards the traffic (based on the Layer 2 multicast forwarding table entry) to Host A on VLAN 10 and to Switch A.

Switch A checks its Layer 3 multicast MLS cache and recognizes that the traffic belongs to a multicast MLS flow. Switch A does not forward the traffic to the router subinterfaces in VLAN 10 (assuming a completely switched flow). Instead, Switch A replicates the traffic on the appropriate outgoing interfaces (VLANs 20 and 30).

VLAN 20 traffic is forwarded to Host C and VLAN 30 traffic is forwarded to Switch C (based on the contents of the Layer 2 multicast forwarding table). The switch performs a packet rewrite for the replicated traffic so that the packets appear to have been routed by the appropriate router subinterface.

Switch C receives the VLAN 30 traffic and forwards it to the appropriate switch ports (in this case, Hosts D and E) using the multicast forwarding table.

If not all the router subinterfaces are eligible to participate in IP multicast MLS, the switch must forward the multicast traffic to the router subinterfaces in the source VLAN (in this case, VLAN 10). In this situation, on those subinterfaces that are ineligible, the routers perform multicast forwarding and replication in software in the usual manner. On those subinterfaces that are eligible, the switch performs multilayer switching.

Note On both MMLS-RPs, no user-configured IP multicast MLS management interface is specified. Therefore, the VLAN 1 subinterface is used by default.

Router A (MMLS-RP) Configuration

```
ip multicast-routing
interface fastethernet1/0.1
 encapsulation isl 1
 ip address 172.20.1.1 255.255.255.0
interface fastethernet1/0.10
 encapsulation isl 10
 ip address 172.20.10.1 255.255.255.0
```

```
 ip pim dense-mode
interface fastethernet1/0.20
 encapsulation isl 20
 ip address 172.20.20.1 255.255.255.0
 ip pim dense-mode
```

Router B (MMLS-RP) Configuration

```
ip multicast-routing
interface fastethernet1/0.1
 encapsulation isl 1
 ip address 172.20.1.2 255.255.255.0
interface fastethernet2/0.10
 encapsulation isl 10
 ip address 172.20.10.100 255.255.255.0
 ip pim dense-mode
interface fastethernet2/0.30
 encapsulation isl 30
 ip address 172.20.30.100 255.255.255.0
 ip pim dense-mode
```

Switch A (MMLS-SE) Configuration

```
Console> (enable) set vlan 10
Vlan 10 configuration successful
Console> (enable) set vlan 20
Vlan 20 configuration successful
Console> (enable) set vlan 30
Vlan 30 configuration successful
Console> (enable) set trunk 1/1 on isl
Port(s) 1/1 trunk mode set to on.
Port(s) 1/1 trunk type set to isl.
Console> (enable) set trunk 1/2 on isl
Port(s) 1/2 trunk mode set to on.
Port(s) 1/2 trunk type set to isl.
Console> (enable) set trunk 1/3 desirable isl
Port(s) 1/3 trunk mode set to desirable.
Port(s) 1/3 trunk type set to isl.
Console> (enable) set trunk 1/4 desirable isl
Port(s) 1/4 trunk mode set to desirable.
Port(s) 1/4 trunk type set to isl.
Console> (enable) set igmp enable
IGMP feature for IP multicast enabled
Console> (enable) set mls multicast enable
Multilayer Switching for Multicast is enabled for this device.
Console> (enable) set mls multicast include 172.20.10.1
Multilayer switching for multicast is enabled for router 172.20.10.1.
Console> (enable) set mls multicast include 172.20.10.100
Multilayer switching for multicast is enabled for router 172.20.10.100.
Console> (enable)
```

Switch B Configuration

The following example shows how to configure Switch B assuming VLAN Trunking Protocol (VTP) is used for VLAN management:

```
Console> (enable) set igmp enable
IGMP feature for IP multicast enabled
Console> (enable)
```

Switch C Configuration

The following example shows how to configure Switch C assuming VTP is used for VLAN management:

```
Console> (enable) set igmp enable
```

```
IGMP feature for IP multicast enabled
Console> (enable)
```

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Configuring IPX Multilayer Switching

This chapter describes how to configure your network to perform IPX Multilayer Switching (MLS). This chapter contains these sections:

- Prerequisites
- Restrictions
- IPX MLS Configuration Task List
- Troubleshooting Tips
- Monitoring and Maintaining IPX MLS on the Router
- IPX MLS Configuration Examples

For a complete description of the commands in this chapter, refer to the the *Cisco IOS Switching Services Command Reference*. To locate documentation of other commands that appear in this chapter, use the command reference master index or search online.

To identify the hardware platform or software image information associated with a feature, use the Feature Navigator on Cisco.com to search for information about the feature or refer to the software release notes for a specific release. For more information, see the section "Identifying Supported Platforms" in the chapter "Using Cisco IOS Software."

Note The information in this chapter is a brief summary of the information contained in the *Catalyst 5000 Series Multilayer Switching User Guide*. The commands and configurations described in this guide apply only to the devices that provide routing services. Commands and configurations for Catalyst 5000 series switches are documented in the *Catalyst 5000 Series Multilayer Switching User Guide*.

Prerequisites

The following prerequisites must be met before IPX MLS can function:

- A VLAN interface must be configured on both the switch and the router. For information on configuring inter-VLAN routing on the RSM or external router, refer to the *Catalyst 5000 Software Configuration Guide*, Release 5.1.

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- IPX MLS must be configured on the switch. For more information refer to the *Catalyst 5000 Software Configuration Guide*, Release 5.1 and the *Catalyst 5000 Command Reference*, Release 5.1.

IPX MLS must be enabled on the router. The minimal configuration steps are described in the section "IPX MLS Configuration Tasks." For more details on configuring IPX routing, refer to the *Cisco IOS AppleTalk and Novell IPX Configuration Guide*.

Restrictions

This section describes restrictions that apply to configuring IPX MLS on the router.

General Configuration Guidelines

Be aware of the following restrictions:

- You must configure the Catalyst 5000 series switch for IPX MLS to work.
- When you enable IPX MLS, the RSM or externally attached router continues to handle all non-IPX protocols, while offloading the switching of IPX packets to the MLS-SE.
- Do not confuse IPX MLS with NetFlow switching supported by Cisco routers. IPX MLS requires both the RSM or directly attached external router and the MLS-SE, but not NetFlow switching on the RSM or directly attached external router. Any switching path on the RSM or directly attached external router will function (process, fast, optimum, and so on).

External Router Guidelines

When using an external router, use the following guidelines:

- Use one directly attached external router per switch to ensure that the MLS-SE caches the appropriate flow information from both sides of the routed flow.
- Use Cisco high-end routers (Cisco 4500, 4700, 7200, and 7500 series) for IPX MLS when they are externally attached to the switch. Make the attachment with multiple Ethernet connections (one per subnet) or by using Fast or Gigabit Ethernet with Inter-Switch Link (ISL) or IEEE 802.1Q encapsulation.
- Connect end hosts through any media (Ethernet, Fast Ethernet, ATM, and FDDI), but connect the external router and the switch only through standard 10/100 Ethernet interfaces, ISL, or IEEE 802.1Q links.

Access List Restrictions

The following restrictions apply when you use access lists on interfaces that participate in IPX MLS:

- Input access lists—Router interfaces with input access lists cannot participate in IPX MLS. If you configure an input access list on an interface, no packets inbound or outbound for that interface are Layer 3 switched, even if the flow is not filtered by the access list. Existing flows for that interface are purged, and no new flows are cached.

Note You can translate input access lists to output access lists to provide the same effect on the interface.

- Output access lists—When an output access list is applied to an interface, the IPX MLS cache entries for that interface are purged. Entries associated with other interfaces are not affected; they follow their normal aging or purging procedures.

  Applying access lists that filter according to packet type, source node, source socket, or destination socket prevents the interface from participating in IPX MLS.

  Applying access lists that use the **log** option prevents the interface from participating in IPX MLS.

- Access list impact on flow masks—Access lists impact the flow mask mode advertised to the MLS-SE by an MLS-RP. If no access list has been applied on any MLS-RP interface, the flow mask mode is destination-ipx (the least specific) by default. If an access list that filters according to the source IPX network has been applied, the mode is source-destination-ipx by default.

Restrictions on Interaction of IPX MLS with Other Features

IPX MLS affects other Cisco IOS software features as follows:

- IPX accounting—IPX accounting cannot be enabled on an IPX MLS-enabled interface.
- IPX EIGRP—MLS is supported for EIGRP interfaces if the Transport Control (TC) maximum is set to a value greater than the default (16).

Restriction on Maximum Transmission Unit Size

In IPX the two endpoints of communication negotiate the maximum transmission unit (MTU) to be used. MTU size is limited by media type.

IPX MLS Configuration Task List

To configure one or more routers for IPX MLS, perform the tasks described in the following sections. The number of tasks you perform depends on your particular configuration.

- Adding an IPX MLS Interface to a VTP Domain (Optional)
- Enabling Multilayer Switching Protocol (MLSP) on the Router (Required)
- Assigning a VLAN ID to a Router Interface (Optional)
- Enabling IPX MLS on a Router Interface (Required)
- Specifying a Router Interface As a Management Interface (Required)

For examples of IPX MLS configurations, see the “IPX MLS Configuration Examples” section later in this document.

Adding an IPX MLS Interface to a VTP Domain

Caution Perform this configuration task only if the switch connected to your router interfaces is in a VTP domain. Perform the task before you enter any other IPX MLS interface command—specifically the **mls rp ipx** or **mls rp management-interface** command. If you enter these commands before adding the interface to a VTP domain, the interface will be automatically placed in a null domain. To place the IPX MLS interface into a domain other than the null domain, clear the IPX MLS interface configuration before you add the interface to another VTP domain. Refer to the section "Configuration, Verification, and Troubleshooting Tips" and the Catalyst 5000 *Software Configuration Guide,* Release 5.1.

Determine which router interfaces you will use as IPX MLS interfaces and add them to the same VTP domain as the switches.

To view the VTP configuration and its domain name on the switch, enter the **show mls rp vtp-domain** EXEC command at the switch Console> prompt.

To assign an MLS interface to a specific VTP domain on the MLS-RP, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# mls rp vtp-domain` *domain-name*	Adds an IPX MLS interface to a VTP domain.

Enabling Multilayer Switching Protocol (MLSP) on the Router

To enable MLSP on the router, use the following command in global configuration mode:

Command	Purpose
`Router(config)# mls rp ipx`	Globally enables MLSP on the router. MLSP is the protocol that runs between the MLS-SE and MLS-RP.

Assigning a VLAN ID to a Router Interface

Note This task is not required for RSM VLAN interfaces (virtual interfaces), ISL-encapsulated interfaces, or IEEE 802.1Q-encapsulated interfaces.

To assign a VLAN ID to an IPX MLS interface, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# mls rp vlan-id` *vlan-id-number*	Assigns a VLAN ID to an IPX MLS interface. The assigned IPX MLS interface must be either an Ethernet or Fast Ethernet interface with no subinterfaces.

Enabling IPX MLS on a Router Interface

To enable IPX MLS on a router interface, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# mls rp ipx`	Enables a router interface for IPX MLS.

Specifying a Router Interface As a Management Interface

To specify an interface as the management interface, use the following command in interface configuration mode:

Command	Purpose
`Router(config-if)# mls rp management-interface`	Specifies an interface as the management interface. MLSP packets are sent and received through the management interface. Select only one IPX MLS interface connected to the switch.

Verifying IPX MLS on the Router

To verify that you have correctly installed IPX MLS on the router, perform the following steps:

Step 1 Enter the **show mls rp ipx** EXEC command.

Step 2 Examine the output to learn if the VLANs are enabled.

Step 3 Examine the output to learn if the switches are listed by MAC address, indicating they are recognized by the MLS-RP.

Troubleshooting Tips

If you entered either the **mls rp ipx** interface command or the **mls rp management-interface** interface command on the interface before assigning it to a VTP domain, the interface will be in the null domain, instead of the VTP domain.

To remove the interface from the null domain and add it to a new VTP domain, use the following commands in interface configuration mode:

	Command	Purpose

Step 1	`Router(config-if)# no mls rp ipx`
	`Router(config-if)# no mls rp management-interface`
	`Router(config-if)# no mls rp vtp-domain` *domain-name*
		Removes an interface from the null domain.

Step 2	`Router(config-if)# mls rp vtp-domain` *domain-name*	Adds the interface to a new VTP domain.

Monitoring and Maintaining IPX MLS on the Router

To monitor and maintain IPX MLS on the router, use the following command in EXEC mode, as needed:

Command	Purpose
`Router# mls rp locate ipx`	Displays information about all switches currently shortcutting for the specified IPX flow(s).
`Router# show mls rp interface type number`	Displays MLS details for a specific interface.
`Router# show mls rp ipx`	Displays details for all IPX MLS interfaces on the router: • MLS status (enabled or disabled) for switch interfaces and subinterfaces. • Flow mask required when creating Layer 3 switching entries for the router. • Current settings for the keepalive timer, retry timer, and retry count. • MLSP-ID used in MLSP messages. • List of interfaces in all VTP domains enabled for MLS.
`Router# show mls rp vtp-domain domain-name`	Displays details about IPX MLS interfaces for a specific VTP domain.

IPX MLS Configuration Examples

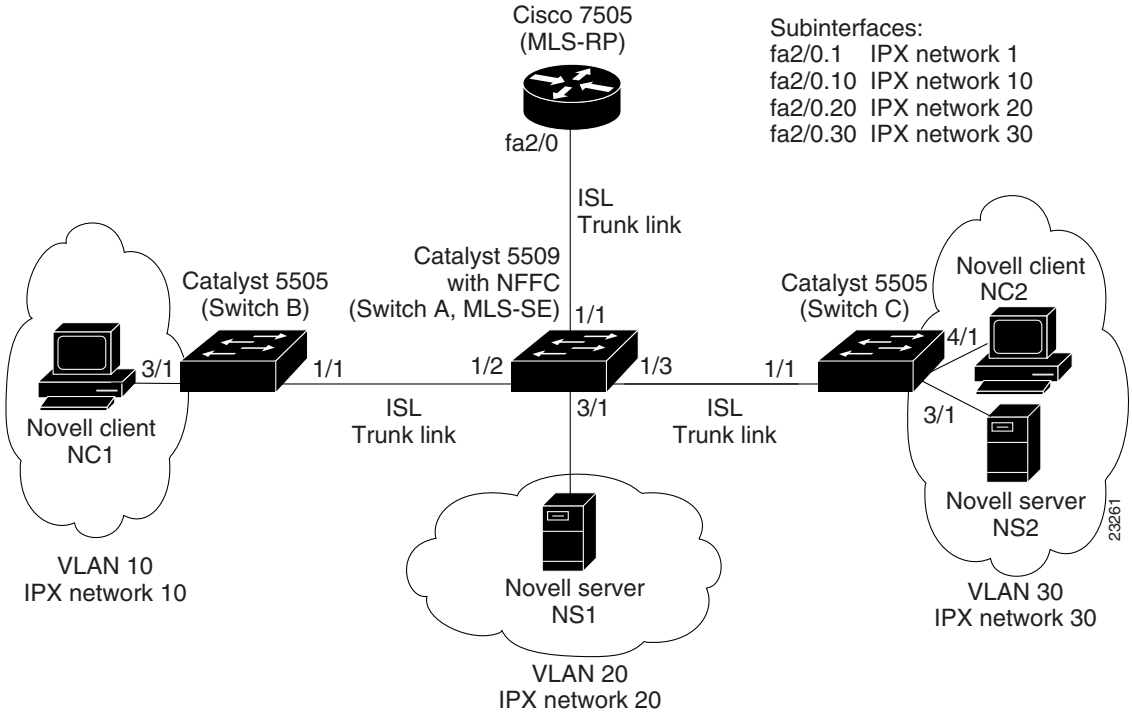
ThisThis example consists of the following sections:

- IPX MLS Network Topology Example
- Operation Before IPX MLS Example
- Operation After IPX MLS Example
- Switch A Configuration
- Switch B Configuration
- Switch C Configuration
- MLS-RP Configuration
- Router with No Access Lists Configuration
- Configuring a Router with a Standard Access List Example

IPX MLS Network Topology Example

Figure 71 shows an IPX MLS network topology consisting of three Catalyst 5000 series switches and a Cisco 7505 router—all interconnected with ISL trunk links.

Figure 71 Example Network: IPX MLS with Cisco 7505 over ISL



The network is configured as follows:

- There are four VLANs (IPX networks):
  - VLAN 1 (management VLAN), IPX network 1
  - VLAN 10, IPX network 10
  - VLAN 20, IPX network 20
  - VLAN 30, IPX network 30
- The MLS-RP is a Cisco 7505 router with a Fast Ethernet interface (interface fastethernet2/0)
- The subinterfaces on the router interface have the following IPX network addresses:
  - fastethernet2/0.1–IPX network 1
  - fastethernet2/0.10–IPX network 10
  - fastethernet2/0.20–IPX network 20
  - fastethernet2/0.30–IPX network 30
- Switch A, the MLS-SE VTP server, is a Catalyst 5509 switch with Supervisor Engine III and the NFFC II.
- Switch B and Switch C are VTP client Catalyst 5505 switches.

Operation Before IPX MLS Example

Before IPX MLS is implemented, when the source host NC1 (on VLAN 10) sends traffic destined for destination server NS2 (on VLAN 30), Switch B forwards the traffic (based on the Layer 2 forwarding table) to Switch A over the ISL trunk link. Switch A forwards the packet to the router over the ISL trunk link.

The router receives the packet on the VLAN 10 subinterface, checks the destination IPX address, and routes the packet to the VLAN 30 subinterface. Switch A receives the routed packet and forwards it to Switch C. Switch C receives the packet and forwards it to destination server NS2. This process is repeated for each packet in the flow between source host NC1 and destination server NS2.

Operation After IPX MLS Example

After IPX MLS is implemented, when the source host NC1 (on VLAN 10) sends traffic destined for destination server NS2 (on VLAN 30), Switch B forwards the traffic (based on the Layer 2 forwarding table) to Switch A (the MLS-SE) over the ISL trunk link. When the first packet enters Switch A, a candidate flow entry is established in the MLS cache. Switch A forwards the packet to the MLS-RP over the ISL trunk link.

The MLS-RP receives the packet on the VLAN 10 subinterface, checks the destination IPX address, and routes the packet to the VLAN 30 subinterface. Switch A receives the routed packet (the enabler packet) and completes the flow entry in the MLS cache for the destination IPX address of NS2. Switch A forwards the packet to Switch C, where it is forwarded to destination server NS2.

Subsequent packets destined for the IPX address of NS2 are multilayer switched by the MLS-SE based on the flow entry in the MLS cache. For example, subsequent packets in the flow from source host NC1 are forwarded by Switch B to Switch A (the MLS-SE). The MLS-SE determines that the packets are part of the established flow, rewrites the packet headers, and switches the packets directly to Switch C, bypassing the router.

Switch A Configuration

This example shows how to configure Switch A (MLS-SE):

```
SwitchA> (enable) set vtp domain Corporate mode server
VTP domain Corporate modified
SwitchA> (enable) set vlan 10
Vlan 10 configuration successful
SwitchA> (enable) set vlan 20
Vlan 20 configuration successful
SwitchA> (enable) set vlan 30
Vlan 30 configuration successful
SwitchA> (enable) set port name 1/1 Router Link
Port 1/1 name set.
SwitchA> (enable) set trunk 1/1 on isl
Port(s) 1/1 trunk mode set to on.
Port(s) 1/1 trunk type set to isl.
SwitchA> (enable) set port name 1/2 SwitchB Link
Port 1/2 name set.
SwitchA> (enable) set trunk 1/2 desirable isl
Port(s) 1/2 trunk mode set to desirable.
Port(s) 1/2 trunk type set to isl.
SwitchA> (enable) set port name 1/3 SwitchC Link
Port 1/3 name set.
SwitchA> (enable) set trunk 1/3 desirable isl
Port(s) 1/3 trunk mode set to desirable.
Port(s) 1/3 trunk type set to isl.
```

```
SwitchA> (enable) set mls enable ipx
IPX Multilayer switching is enabled.
SwitchA> (enable) set mls include ipx 10.1.1.1
IPX Multilayer switching enabled for router 10.1.1.1.
SwitchA> (enable) set port name 3/1 Destination D2
Port 3/1 name set.
SwitchA> (enable) set vlan 20 3/1
VLAN 20 modified.
VLAN 1 modified.
VLAN  Mod/Ports
---- ----------------------
20    3/1

SwitchA> (enable)
```

Switch B Configuration

This example shows how to configure Switch B:

```
SwitchB> (enable) set port name 1/1 SwitchA Link
Port 1/1 name set.
SwitchB> (enable) set port name 3/1 Source S1
Port 3/1 name set.
SwitchB> (enable) set vlan 10 3/1
VLAN 10 modified.
VLAN 1 modified.
VLAN  Mod/Ports
---- ----------------------
10    3/1

SwitchB> (enable)
```

Switch C Configuration

This example shows how to configure Switch C:

```
SwitchC> (enable) set port name 1/1 SwitchA Link
Port 1/1 name set.
SwitchC> (enable) set port name 3/1 Destination D1
Port 3/1 name set.
SwitchC> (enable) set vlan 30 3/1
VLAN 30 modified.
VLAN 1 modified.
VLAN  Mod/Ports
---- ----------------------
30    3/1

SwitchC> (enable) set port name 4/1 Source S2
Port 4/1 name set.
SwitchC> (enable) set vlan 30 4/1
VLAN 30 modified.
VLAN 1 modified.
VLAN  Mod/Ports
---- ----------------------
30    3/1
      4/1

SwitchC> (enable)
```

MLS-RP Configuration

This example shows how to configure the MLS-RP:

```
mls rp ipx
interface fastethernet 2/0
 full-duplex
 mls rp vtp-domain Engineering
interface fastethernet2/0.1
 encapsulation isl 1
 ipx address 10.1.1.1 255.255.255.0
 mls rp ipx
 mls rp management-interface
interface fastethernet2/0.10
 encapsulation isl 10
 ipx network 10
 mls rp ipx
interface fastethernet2/0.20
 encapsulation isl 20
 ipx network  20
 mls rp ipx
interface fastethernet2/0.30
 encapsulation isl 30
 ipx network 30
 mls rp ipx
```

This example shows how to configure the RSM VLAN interfaces with no access lists. Therefore, the flow mask mode is destination.

```
Building configuration...

Current configuration:
!
version 12.0

.
.
.
ipx routing 0010.0738.2917
mls rp ip
mls rp ipx

.
.
.
interface Vlan21
 ip address 10.5.5.155 255.255.255.0
 ipx network 2121
 mls rp vtp-domain Engineering
 mls rp management-interface
 mls rp ip
 mls rp ipx
!
interface Vlan22
ip address 10.2.2.155 255.255.255.0
 ipx network 2222
 mls rp vtp-domain Engineering
 mls rp ip
 mls rp ipx
!
.
.
.
end
Router# show run
```

```
Building configuration...
Current configuration:
!
version 12.0
!
interface Vlan22
ip address 10.2.2.155 255.255.255.0
 ipx access-group 800 out
 ipx network 2222
 mls rp vtp-domain Engineering
 mls rp ip
 mls rp ipx
!

.
.
.
!
!
!

access-list 800 deny 1111 2222
access-list 800 permit FFFFFFFF FFFFFFFF

.
.
.
end
```

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cGVRP

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The Compact (c) Generic Attribute Registration Protocol (GARP) VLAN Registration Protocol (GVRP) feature reduces CPU time for transmittal of 4094 VLAN states on a port.

Finding Feature Information in This Module

Your Cisco IOS software release may not support all of the features documented in this module. To reach links to specific feature documentation in this module and to see a list of the releases in which each feature is supported, use the "clear gvrp statistics" section on page 19.

Finding Support Information for Platforms and Cisco IOS and Catalyst OS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Contents

- Restrictions for cGVRP, page 1
- Information About cGVRP, page 2
- How to Configure cGVRP, page 4
- Configuration Examples for cGVRP, page 7
- Additional References, page 16
- Command Reference, page 17

Restrictions for cGVRP

- A non-Cisco device can only interoperate with a Cisco device through .1Q trunks.
- VLAN Mapping is not supported with GVRP.

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- cGVRP and Connectivity Fault Management(CFM) can coexist but if the line card (LC) or supervisor does not have enough mac-match registers to support both protocols, the cGVRP ports on those LCs are put in error disabled state. To use Layer 2 functionality, disable cGVRP on those ports and configure shut/no shut.
- cGVRP functionality applies only to interfaces configured for Layer 2 (switchport) functionality.
- Native VLAN Tagging causes frames sent to the native VLAN of the .1Q trunk ports to be encapsulated with .1Q tags. Problems may arise with other GVRP participants on the LAN because they may not be able to admit tagged GVRP PDUs. Caution must be exercised if both features are enabled at the same time.
- 802.1X authentication and authorization takes place after the port becomes link-up and before the Dynamic Trunking Protocol (DTP) negotiations start prior to GVRP running on the port.
- Port Security works independently from GVRP and it may be limited to the number of other GVRP participants on a LAN that a GVRP enabled port on a device can communicate with.
- GVRPs cannot be configured and run on a sub-interface.
- GVRP and UniDirectional Link Routing (UDLR) should not be enabled on the same interface because UDLR limits frames in one direction on the port and GVRP is a two way communication protocol.
- Additional memory is required to store GARP/GVRP configurations and states per GVRP enabled port, but it can be dynamically allocated on demand.
- GARP Multicast Registration Protocol (GMRP) is not supported.

Information About cGVRP

To configure cGVRP, you should understand the following concepts:

- GARP/GVRP Definition, page 2
- cGVRP Overview, page 2
- How to Configure cGVRP, page 4

GARP/GVRP Definition

GVRP enables automatic configuration of switches in a VLAN network allowing network devices to dynamically exchange VLAN configuration information with other devices. GVRP is based on GARP which defines procedures for registering and deregistering attributes with each other. It eliminates unnecessary network traffic by preventing attempts to transmit information to unregistered users.

GVRP is defined in IEEE 802.1Q.

cGVRP Overview

GVRP is a protocol that requires extensive CPU time in order to transmit all 4094 VLAN states on a port. In Compact mode only one PDU is sent and it includes the states of all the 4094 VLANs on a port.

VLAN pruning can be accomplished faster by running in a special mode, Fast Compact Mode, and on point-to-point links.

In Compact GVRP a GVRP PDU may be sent out the port if the port is in forwarding state in a spanning tree instance. GVRP PDUs must be transmitted in the native VLAN of .1Q trunks.

GVRP Interoperability with VTP and VTP Pruning

VTP Pruning is an extension of VTP. It has its own Join message that can be exchanged with VTP PDUs. VTP PDUs can be transmitted on both .1Q trunks and ISL trunks. A VTP capable device is in either one of the three VTP modes: Server, Client, or Transparent.

When VTP Pruning and GVRP are both enabled globally, VTP Pruning is run on ISL trunks, and GVRP is run on .1Q trunks.

Compact GVRP has two modes: Slow Compact Mode, and Fast Compact Mode. A port can be in Fast Compact Mode if it has one GVRP enabled peer on the same LAN segment, and the peer is capable of operating in Compact Mode. A port is in Slow Compact Mode if there are multiple GVRP participants on the same LAN segment operating in Compact Mode.

GVRP interoperability with Other Software Features and Protocols

STP

Spanning Tree Protocol (STP) may run in one of the three STP modes: Multiple Spanning Tree(MST), Per VLAN Spanning Tree (PVST), or Rapid PVST. An STP mode range causes the forwarding ports to leave the forwarding state as STP has to reconverge. This may cause GVRP to have its own topology change as Join messages my be received on some new ports and Leave timers may expire on some others.

DTP

DTP negotiates the port mode (trunk vs. non-trunk) and the trunk encapsulation type between two DTP enabled ports. After negotiation DTP may set the port to either ISL trunk, or .1Q trunk, or non trunk. DTP negotiation occurs after ports become link-up and before they become forwarding in spanning trees. If GVRP is administratively enabled on a port and the device, it should be initialized after the port is negotiated to be a .1Q trunk.

VTP

VTP version 3 expands the range of VLANs that can be created and removed via VTP. VTP Pruning is available for VLAN 1 - 1005 only.

EtherChannel

When multiple .1Q trunk ports are grouped by either Port Aggregation Protocol (PAgP) or Link Aggregation Control Protocol (LACP) to become an etherchannel, the etherchannel can be configured as a GVRP participant. The physical ports in the etherchannel cannot be GVRP participants by themselves. Since an etherchannel is treated like one virtual port by STP, the GVRP application can learn the STP state change of the etherchannel just like any physical port. The etherchannel, not the physical ports in the channel, constitutes the GARP Information Propagation (GIP) context.

High Availability

High Availability (HA) is a redundancy feature in IOS. On platforms that support HA and State SwitchOver (SSO), many features and protocols my resume working in a couple of seconds after the system encounters a failure such as a crash of the active supervisor in a Catalyst 7600 switch. GVRP needs to be configured to enable user configurations, and protocol states should be synched to a standby system. If there is a failure of the active system, the GVRP in the standby system which now becomes active, has all the up-to-date VLAN registration information.

How to Configure cGVRP

:This procedure contains the following tasks:

- Configuring Compact GVRP, page 4
- Disabling mac-learning on VLANs, page 5
- Enabling a Dynamic VLAN: Example, page 8

Configuring Compact GVRP

To configure compact GVRP, perform the following task.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **gvrp global**
4. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**grvp global** **Example:** `Router(config)# gvrp global`	Configures global GVRP and enables GVRP on all .1Q trunks.

	Command or Action	Purpose
Step 4	**interface** *type number* **Example:** `Router(config)# interface GigabitEthernnet 12/15`	Exits configuration mode.
Step 5	**gvrp timer join** *timer-value* **Example:** `Router(config-if)# gvrp timer join 1000`	Sets the period timers.
Step 6	**gvrp registration normal** **Example:** `Router(config-if)# gvrp registration normal`	Sets the registrar for normal response to incoming GVRP messages.

Disabling mac-learning on VLANs

To disable mac-learning on VLANs, perform the following task.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **gvrp mac-learning auto**
4. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**gvrp mac-learning auto** **Example:** `Router(config)# gvrp mac-learning auto`	Disables learning of mac-entries.
Step 4	**exit** **Example:** `Router(config)# exit`	Exits configuration mode.

Enabling a Dynamic VLAN

To enable a dynamic VLAN, perform the following task.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **gvrp vlan create**
4. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**gvrp vlan create** **Example:** `Router(config)# gvrp vlan create`	Enables a dynamic VLAN when cGRVP is configured.
Step 4	**exit** **Example:** `Router(config)# exit`	Exits configuration mode.

Troubleshooting the cGVRP Configuration

Perform this task to troubleshoot the cGVRP configuration.

Use the show gvrp summary and show gvrp interface commands to display configuration information and interface states, and the debug gvrp command to enable all or a limited output messages related to an interface.

SUMMARY STEPS

1. **enable**
2. **show gvrp summary**
3. show gvrp interface
4. **debug gvrp**
5. **clear gvrp statistics**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show gvrp summary** **Example:** `Router# show gvrp summary`	Displays the GVRP configuration.
Step 3	**show gvrp interface** **Example:** `Router# show gvrp interface`	Displays the GVRP interface states.
Step 4	**debug gvrp** **Example:** `Router# debug gvrp`	Displays GVRP debugging information.
Step 5	**clear gvrp statistics** **Example:** `Router# clear gvrp statistics interface 12/15`	Clears GVRP statistics on all interfaces.

Configuration Examples for cGVRP

This section provides the following configuration examples:

• Configuring cGVRP: Example, page 8

- Verifying CE Ports Configured as Access Ports: Example, page 8
- Enabling a Dynamic VLAN: Example, page 8
- Verifying CE Ports Configured as Access Ports: Example, page 8
- Verifying CE Ports Configured as ISL Ports: Example, page 10
- Verifying CE Ports Configured in Fixed Registration Mode: Example, page 12
- Verifying CE Ports Configured in Forbidden Registration Mode: Example, page 12
- Verifying cGVRP: Example, page 13
- Verifying Disabled mac-learning on VLANs: Example, page 13
- Verifying Dynamic VLAN: Example, page 14
- Verifying Local Association Due to .1q trunk: Example, page 14

Configuring cGVRP: Example

The following example shows how to configure compact GVRP.

```
Router(config)# gvrp global
```

Disabling mac-learning on VLANs: Example

The following example shows how to disable mac-learning on VLANs configured with cGVRP.

```
Router(config)# gvrp mac-learning auto
```

Enabling a Dynamic VLAN: Example

The following example shows how to configure a dynamic VLAN.

```
Router(config)# gvrp global
```

Verifying CE Ports Configured as Access Ports: Example

Topology:

CE1 - gi3/15 R1 gi3/1 - dot1q trunk - gi3/1 R2 gi12/15 - CE2

```
R1#show running-config interface gi3/15
Building configuration...

Current configuration : 129 bytes
!
interface GigabitEthernet3/15
 switchport
 switchport access vlan 2
 switchport mode access
 spanning-tree portfast trunk
end

R1#show running-config interface gi3/1
Building configuration...
```

```
Current configuration : 109 bytes
!
interface GigabitEthernet3/1
 switchport
 switchport trunk encapsulation dot1q
 switchport mode trunk
end

R2#show running-config interface gi12/15
Building configuration...

Current configuration : 168 bytes
!
interface GigabitEthernet12/15
 switchport
 switchport access vlan 2
 switchport trunk encapsulation dot1q
 switchport mode access
 spanning-tree portfast trunk
end

R2#show running-config interface gi3/1
Building configuration...

Current configuration : 144 bytes
!
interface GigabitEthernet3/1
 switchport
 switchport trunk encapsulation dot1q
 switchport mode trunk
 switchport backup interface Gi4/1
end

R1#show gvrp summary
GVRP global state           : enabled
GVRP VLAN creation          : disabled
VLANs created via GVRP      : none
MAC learning auto provision : disabled
Learning disabled on VLANs  : none

R1#show gvrp interface
Port      Status    Mode            Registrar State
Gi3/1     on        fastcompact        normal

Port      Transmit Timeout   Leave Timeout   Leaveall Timeout
Gi3/1     200                600             10000

Port      Vlans Declared
Gi3/1     2

Port      Vlans Registered
Gi3/1     2

Port      Vlans Registered and in Spanning Tree Forwarding State
Gi3/1     2

R2#show gvrp summary
GVRP global state           : enabled
GVRP VLAN creation          : disabled
VLANs created via GVRP      : none
MAC learning auto provision : disabled
Learning disabled on VLANs  : none

R2#show gvrp interface
```

```
Port      Status    Mode            Registrar State
Gi3/1     on        fastcompact        normal

Port      Transmit Timeout   Leave Timeout   Leaveall Timeout
Gi3/1     200                600             10000

Port      Vlans Declared
Gi3/1     2

Port      Vlans Registered
Gi3/1     2

Port      Vlans Registered and in Spanning Tree Forwarding State
Gi3/1     2
```

Verifying CE Ports Configured as ISL Ports: Example

```
Topology

CE1 – gi3/15 R1 gi3/1 - dot1q trunk - gi3/1 R2 gi12/15 – CE2

R1#show running-config interface gi3/15
Building configuration...

Current configuration : 138 bytes
!
interface GigabitEthernet3/15
 switchport
 switchport trunk encapsulation isl
 switchport mode trunk
 spanning-tree portfast trunk
end

R1#show running-config interface gi3/1
Building configuration...

Current configuration : 109 bytes
!
interface GigabitEthernet3/1
 switchport
 switchport trunk encapsulation dot1q
 switchport mode trunk
end

R2#show running-config interface gi12/15
Building configuration...

Current configuration : 139 bytes
!
interface GigabitEthernet12/15
 switchport
 switchport trunk encapsulation isl
 switchport mode trunk
 spanning-tree portfast trunk
end

R2#show running-config interface gi3/1
Building configuration...

Current configuration : 144 bytes
!
interface GigabitEthernet3/1
```

```
 switchport
 switchport trunk encapsulation dot1q
 switchport mode trunk
 switchport backup interface Gi4/1
end

R1#show gvrp summary
GVRP global state           : enabled
GVRP VLAN creation          : disabled
VLANs created via GVRP      : none
MAC learning auto provision : disabled
Learning disabled on VLANs  : none

R1#show gvrp interface
Port      Status    Mode            Registrar State
Gi3/1     on        fastcompact        normal

Port      Transmit Timeout   Leave Timeout   Leaveall Timeout
Gi3/1     200                600             10000

Port      Vlans Declared
Gi3/1     1-10

Port      Vlans Registered
Gi3/1     1-2

Port      Vlans Registered and in Spanning Tree Forwarding State
Gi3/1     1-2

R1#sh vlan sum
Number of existing VLANs           : 14
 Number of existing VTP VLANs      : 14
 Number of existing extended VLANs : 0

R2#show gvrp summary
GVRP global state           : enabled
GVRP VLAN creation          : disabled
VLANs created via GVRP      : none
MAC learning auto provision : disabled
Learning disabled on VLANs  : none

R2#show gvrp interface
Port      Status    Mode            Registrar State
Gi3/1     on        fastcompact        normal

Port      Transmit Timeout   Leave Timeout   Leaveall Timeout
Gi3/1     200                600             10000

Port      Vlans Declared
Gi3/1     1-2

Port      Vlans Registered
Gi3/1     1-10

Port      Vlans Registered and in Spanning Tree Forwarding State
Gi3/1     1-2

R2#sh vlan sum
Number of existing VLANs           : 6
 Number of existing VTP VLANs      : 6
 Number of existing extended VLANs : 0
```

Verifying CE Ports Configured in Fixed Registration Mode: Example

```
Router1 #show running-config interface gi3/15
Building configuration...

Current configuration : 165 bytes
!
interface GigabitEthernet3/15
 gvrp registration fixed
 switchport
 switchport trunk encapsulation dot1q
 switchport mode trunk
 spanning-tree portfast trunk
end

Router1 #show gvrp interface gigabitEthernet 3/15
Port      Status    Mode            Registrar State
Gi3/15    on        fastcompact        fixed

Port      Transmit Timeout   Leave Timeout   Leaveall Timeout
Gi3/15    200                600             10000

Port      Vlans Declared
Gi3/15    1-2

Port      Vlans Registered
Gi3/15    1-4094

Port      Vlans Registered and in Spanning Tree Forwarding State
Gi3/15    1-10
```

Verifying CE Ports Configured in Forbidden Registration Mode: Example

```
Router1 #show running-config interface gi3/15
Building configuration...

Current configuration : 169 bytes
!
interface GigabitEthernet3/15
 gvrp registration forbidden
 switchport
 switchport trunk encapsulation dot1q
 switchport mode trunk
 spanning-tree portfast trunk
end

Router1 #show gvrp interface gigabitEthernet 3/15
Port      Status    Mode            Registrar State
Gi3/15    on        fastcompact     forbidden

Port      Transmit Timeout   Leave Timeout   Leaveall Timeout
Gi3/15    200                600             10000

Port      Vlans Declared
Gi3/15    1-2

Port      Vlans Registered
Gi3/15    none

Port      Vlans Registered and in Spanning Tree Forwarding State
```

```
Gi3/15    none
```

Verifying cGVRP: Example

The following example shows how to verify the compact GVRP configuration.

```
Router# show gvrp summary

GVRP global state           : enabled
GVRP VLAN creation          : disabled
VLANs created via GVRP      : none
MAC learning auto provision : disabled
Learning disabled on VLANS  : none
```

Verifying Disabled mac-learning on VLANs: Example

The following examples show how to verify that mac-learning has been disabled.

```
Router# show gvrp summary
GVRP global state           : enabled
GVRP VLAN creation          : enabled
VLANs created via GVRP      : 2-200
MAC learning auto provision : enabled
Learning disabled on VLANs  : 1-200

Router# show gvrp interface

Port      Status    Mode            Registrar State
Gi3/15    on        fastcompact        normal
Gi4/1     on        fastcompact        normal

Port      Transmit Timeout   Leave Timeout   Leaveall Timeout
Gi3/15    200                600             10000
Gi4/1     200                600             10000

Port      Vlans Declared
Gi3/15    1-200
Gi4/1     none

Port      Vlans Registered
Gi3/15    none
Gi4/1     1-200

Port      Vlans Registered and in Spanning Tree Forwarding State
Gi3/15    none
Gi4/1     1-200

Router# show mac- dy
Legend: * - primary entry
        age - seconds since last seen
        n/a - not available

  vlan   mac address     type    learn     age              ports
------+----------------+--------+-----+----------+--------------------------
No entries present.
```

Verifying Dynamic VLAN: Example

The following examples show how to verify the GVRP summary and interface.

```
Router# show gvrp summary

GVRP global state           : enabled
GVRP VLAN creation          : enabled
VLANs created via GVRP      : 2-200
MAC learning auto provision : disabled
Learning disabled on VLANs  : none

Router# show gvrp interface

Port      Status    Mode            Registrar State
Gi3/15    on        fastcompact         normal
Gi4/1     on        fastcompact         normal

Port      Transmit Timeout   Leave Timeout   Leaveall Timeout
Gi3/15    200                600             10000
Gi4/1     200                600             10000

Port      Vlans Declared
Gi3/15    1-200
Gi4/1     none

Port      Vlans Registered
Gi3/15    none
Gi4/1     1-200

Port      Vlans Registered and in Spanning Tree Forwarding State
Gi3/15    none
Gi4/1     1-200
```

Verifying Local Association Due to .1q trunk: Example

Topology

CE1 – gi3/15 R1 gi3/1 - dot1q trunk - gi3/1 R2 gi12/15 – CE2

```
Router1 #show running-config interface gi3/15
Building configuration...

Current configuration : 165 bytes
!
interface GigabitEthernet3/15
 gvrp registration fixed
 switchport
 switchport trunk encapsulation dot1q
 switchport mode trunk
 spanning-tree portfast trunk
end

Router2 #show running-config interface gi12/15
Building configuration...

Current configuration : 166 bytes
!
interface GigabitEthernet12/15
 gvrp registration fixed
 switchport
 switchport trunk encapsulation dot1q
```

```
 switchport mode trunk
 spanning-tree portfast trunk
end

Router1 #show gvrp summary
GVRP global state           : enabled
GVRP VLAN creation          : disabled
VLANs created via GVRP      : none
MAC learning auto provision : disabled
Learning disabled on VLANs  : none

Router1 #show gvrp interface
Port      Status    Mode            Registrar State
Gi3/1     on        fastcompact        normal
Gi3/15    on        fastcompact        fixed

Port      Transmit Timeout   Leave Timeout   Leaveall Timeout
Gi3/1     200                600             10000
Gi3/15    200                600             10000

Port      Vlans Declared
Gi3/1     1-10
Gi3/15    1-2

Port      Vlans Registered
Gi3/1     1-2
Gi3/15    1-4094

Port      Vlans Registered and in Spanning Tree Forwarding State
Gi3/1     1-2
Gi12/15   1-10

R2#show gvrp summary
GVRP global state           : enabled
GVRP VLAN creation          : disabled
VLANs created via GVRP      : none
MAC learning auto provision : disabled
Learning disabled on VLANs  : none

R2#show gvrp interface
Port      Status    Mode            Registrar State
Gi3/1     on        fastcompact         normal
Gi12/15   on        fastcompact         fixed

Port      Transmit Timeout   Leave Timeout   Leaveall Timeout
Gi3/1     200                600             10000
Gi12/15   200                600             10000

Port      Vlans Declared
Gi3/1     1-2
Gi12/15   1-2

Port      Vlans Registered
Gi3/1     1-10
Gi12/15   1-4094

Port      Vlans Registered and in Spanning Tree Forwarding State
Gi3/1     1-2
Gi12/15   1-2
```

Additional References

The following sections provide references related to the cGVRP feature.

Related Documents

Related Topic	Document Title
LAN Switching commands: complete command syntax, command mode, defaults, command history, usage guidelines, and examples	*Cisco IOS LAN Switching Command Reference*, Release 12.2SR

Standards

Standard	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

MIB	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFC	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	—

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password. If you have a valid service contract but do not have a user ID or password, you can register on Cisco.com.	http://www.cisco.com/techsupport

Feature Information for cGVRP

Table 1 lists the release history for this feature.

Not all commands may be available in your Cisco IOS software release. For release information about a specific command, see the command reference documentation.

Use Cisco Feature Navigator to find information about platform support and software image support. Cisco Feature Navigator enables you to determine which Cisco IOS and Catalyst OS software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn. An account on Cisco.com is not required.

Note Table 1 lists only the Cisco IOS software release that introduced support for a given feature in a given Cisco IOS software release train. Unless noted otherwise, subsequent releases of that Cisco IOS software release train also support that feature.

Table 1 Feature Information for cGVRP

Feature Name	Releases	Feature Information
cGVRP	12.2(33)SRB	The Compact (c) Generic Attribute Registration Protocol (GARP) VLAN Registration Protocol (GVRP) feature reduces CPU time for transmittal of 4094 VLAN states on a port. GVRP enables automatic configuration of switches in a VLAN network allowing network devices to dynamically exchange VLAN configuration information with other devices. GVRP is based on GARP which defines procedures for registering and deregistering attributes with each other. It eliminates unnecessary network traffic by preventing attempts to transmit information to unregistered users. GVRP is defined in IEEE 802.1Q. The following commands were introduced or modified to support this feature: **clear gvrp statistics, debug gvrp, gvrp global, gvrp mac-learning, gvrp registration, gvrp timer, gvrp vlan create, show gvrp interface, show gvrp summary** For information about these commands, see the *Cisco IOS LAN Switching Command Reference* at http://www.cisco.com/en/US/docs/ios/lanswitch/command/reference/lsw_book.html. For information about all Cisco IOS commands, go to the Command Lookup Tool at http://tools.cisco.com/Support/CLILookup or to the *Cisco IOS Master Commands List*.

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